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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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The B.C.I.R.A. Scottish Laboratories are:—
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Forthcoming Events.

NOVEMBER 2.

Institution of Engineering Inspection:—Opening meeting in London. "Die Casting," Paper by A. H. Mundey.

NOVEMBER 6.

Institute of Metals (Birmingham Local Section):—Ordinary meeting at Birmingham. "Drop Forging and Machine Forging," Paper by F. W. Spencer.

Institute of Metals (North-East Coast Local Section):—Ordinary meeting at Newcastle-on-Tyne. "Deformation of Metals," Paper by Professor Cecil H. Desch, F.R.S.

NOVEMBER 8.

Institute of Metals (London Local Section):—Ordinary meeting in London. "The Plastic Contour," Paper by Professor W. E. Dalby, F.R.S.

NOVEMBER 9.

Institute of Metals (Sheffield Local Section):—Ordinary meeting at Sheffield. "Flow in Metal Shaping Processes," Paper by Professor F. C. Thompson, D.Met.

NOVEMBER 21-22.

Institute of Fuel:—Meetings at the Institution of Electrical Engineers, London, W.C.2. Papers to be read:—"Production," by George Raw, B.Sc.; "Preparation," by Prof. H. Louis; "Marketing," by Capt. Roland Addy.

Institute of British Foundrymen.

NOVEMBER 3.

Lancashire Branch:—Ordinary meeting at Manchester. "Facing Sands," Paper by C. Presswood, B.A.

NOVEMBER 8.

London Branch:—Ordinary meeting in London. "Consideration of Points Raised in P. Bardenheuers' Paper, Graphite in Gray Cast Iron," by John Shaw.

Birmingham, Coventry and West Midlands Branch:—Ordinary meeting in Birmingham. "Shrinkage Holes in Small Grey Iron Castings," Paper by P. A. Russell.

NOVEMBER 10.

Birmingham Branch (Junior Section):—Ordinary meeting. "Patterns: Good and Bad," Paper by W. J. Flavell.

I.B.F. Winter Programmes.

The winter programmes of the technical societies have set in, as someone once said of the English summer, "with their accustomed severity." As a consequence of a good deal of summer-time thought and effort, energetic secretaries have produced an attractive list of meetings and visits, and the combined list of I.B.F. programmes has come to hand.

A perusal of the programmes makes clear the importance of what might be termed the educational aspect of the work of the Institute. Most technical societies, particularly those of senior rank, are content to present each winter a comparatively small number of Papers dealing in the main with new work, and their provincial branches are content to take their Papers from headquarters. Furthermore, they do not generally discuss Papers at their annual meetings. The I.B.F., however, is different. Foundry work is so complex and many sided that there is always room for the presentation of a particular type of experience, even though the Paper may be descriptive, or may not embody really novel matter. Members vary so much in their technical knowledge and practical experience that this constant re-presenting of important aspects of foundry work is a good thing. If at some future date the Institute decides to impose some form of qualification on younger men desiring to enter, the Papers of the proceedings will form an admirable set of text books for them to study.

In connection with the Papers, it should be remembered that they are like mercy, which blesses both him that gives and him that takes. There is nothing more useful to a foundryman than to attempt to put down on paper certain ideas and to give them to an audience. Whether the audience get anything out of it or not, the speaker gains enormously in the clarity of his ideas, because he is compelled to put into words things which often lie unexpressed at the back of his mind. A further advantage is gained by discussion with other men of similar responsibility but different experience. Equally also the audience gets something from a presentation of certain facts, and those who contribute to the discussion get in a lesser degree some of the advantages which the speaker has gained from preparing the Paper.

More and more manufacturers rely upon organisation and management for their power to compete, rather than upon the possession of so-called trade secrets, and increasingly is the man who attends technical meetings free to put his cards on the table. The I.B.F. has an enormous part to play in providing a platform on which this interchange of idea can take place. We think that the secretaries might with advantage cultivate the younger men who are keen, but who have not yet commenced to write, and also try and get material from those older men of wide experience but who do not write easily, by associating them with a suitable younger man. This works very well when the two men have confidence in each other. Finally, we would appeal to Branch-Presidents, Chairmen and others not to pad out a discussion by relying on the efforts of the usual speakers, who can, if necessary, be called upon to fill an awkward gap later in the evening. We think some excellent meetings could be held by having impromptu discussions on topics which are not known until the meeting opens, these forming what the B.B.C. would call "surprise items." Alternatively an excellent evening can be arranged by getting, say, half a dozen members to contribute to a discussion on a topic which wants ventilating, although an actual Paper may not be forthcoming.

Quasi and Crazy Scientific Developments.

There is an attitude abroad amongst the more scientific section of the foundry world of shelving or disregarding improvements in melting machines, proprietary articles, or cast iron metallurgy, because this body of thought regards these developments as being at present unrelated to the final solution of the problem posed. Now it has recently been stated that the institution of mass or quantity production and "standards" is an acknowledgment of a lull in progress. The steel rail has been standardised for many years, yet we believe it could be improved upon, but it obviously "fills the bill," and allows progress to be built upon its proved properties. Thus when the founder is offered a guaranteed improvement the question arises as to whether by its adoption progress can be built up around its functioning. For instance, if it is an economical system of melting, any savings could be devoted to the better grading of the raw materials or a fund created for mechanical handling. If it is a question of the use of a proprietary article, which introduces economies, a period of standardisation should permit of added time to be devoted to various shop problems. If the improvement relates to better, but more expensive, finished product then studies should be made for educating the buyer as to the advantages of the new material and the *raison d'être* for an increased price and generally to effect the creation of an added profit from the material. Then an allocation should be made to

work away for the complete understanding of the new material and its correlation and co-ordination with academic research work. Thus the creation of a mental metallurgical rut may be circumvented. Finally there is being issued a certain number of purely quack nostrums, for which no definite chemical or logical practical reasons can be advanced for their economic utilisation. These can be relegated to the "crazy" variety, and can be dismissed without further consideration, but the "quasi" merit the closest consideration, even though they do create a temporary lull in progress, because, like quantity production, it is the safest basis for the immediate production of profit. The receipt of war debts in the distant future should provide posterity with the means of providing an academic basis for every operation performed and material produced.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Foundry and Engineering Training on the Continent.

To the Editor of The Foundry Trade Journal.

Sir,—As I listened to Mr. Delport's address to the London Branch of the I.B.F. on the above subject his concise review of the curriculum advocated and carried out by the Foundry High School of Paris, the successes obtained and fine work done, my first thoughts were Germany does not possess all the thoroughness associated with "technical education." I should like, here and now, to congratulate the French Foundry Masters' Association, coupling with them the French Educational Authorities and M. Ronceray. I do admire their courage and initiative in pushing through a scheme of this description. In regard to practical training, the moulder of Great Britain compares most favourably with those of Germany, France and America, where specialisation is a noted feature, this undoubtedly being detrimental to the production of good all-round moulders. I will admit that the "technical" instruction absorbed by our youths in the foundries is not comparable with such as is regularly given at the Paris High School, viz., eight years of technical and practical instruction. What would our apprentices think of that? And the last two years at the day school; the fees approximate to £50 at least per annum. By all means let us have such schools for those who can afford to pay. For instance, a two-years' course in such a school for future owners, partners, directors, superintendents and works managers would be all to the good of the industry and its workers. It would surely be the means of raising the morale and status of the workers engaged thereon in the eyes of those that mattered. But to ask ourselves such a question as "Do our moulders and apprentices require such a school exactly after this style?" is, I think, superfluous. Rather ask, "Can they or their parents afford to send them to such a school?" The answer will be "No" in the large majority of cases. I firmly believe that the educational authorities can and will meet any demand for the training of the foundry employees. Facilities already exist in London and the provinces for an ideal training. But we have not had any authoritative demand for a stabilised course of instruction. Nothing was given to us by Mr. Delport as being in the "Course of Studies" pursued under the French system but what is already provided by our own Institutes, viz., arithmetic, geometry, chemistry, mathematics, machine-drawing, physics, metallurgy, pyrometry, testing of metals, and practical work in pattern-making and foundry practice. My final suggestion is that the foundry-owners get together, and form a new association of their own; follow the example outlined by Mr. Delport; enlist Governmental aid; formulate a systematic course of studies; grant recognised certificates and diplomas for successes at examinations; and then I am sure, with the programme arranged and the certainty of some suitable recognition for services rendered, that the apprentices and moulders will not be found wanting.—Yours, etc.,

A. F. Gibbs.

L.N.E.R., C.M.E. Dept., Stratford.

Big Foundry Fusion Now Carried Out.

£450,000 Share Capital.

The proposed big Derby foundry fusion recently reported in the columns of The Foundry Trade Journal, has now been carried out, and the name of the new firm, which has taken over the amalgamated business of Messrs. Haslam's Foundry and Engineering Company, Limited, and Messrs. Newton Bros., Limited, will be known as Messrs. Haslam & Newton, Limited.

The directors of the new company are Mr. Jesse Lord, J.P., of Rochdale, who was chairman of the Haslam Foundry & Engineering Company (1927), Limited; Mr. William Gilbert Haslam, J.P., North Lees, Derby, director of the Haslam Company; Mr. Charles Andrew Newton, A.M.I.E.E., Park Lane House, Littleover, Derby, chairman of Newton Bros. (Derby), Limited; Lt.-Col. H. Newton, C.B.E., D.S.O., T.D., Mile Ash, Derby, a director of Newton Bros. and managing director of Raylock Fabrics, Limited; Mr. Gerardus Johannes Tennisen, Berkheide, Rijksdorp, Wassenaar, Holland, Continental representative; Mr. Henry Bland Potter, managing director of Haslams; and Mr. Frederick Newton, The Grange, Normanton, Derby, the managing director of Newton Bros.

It will be noticed that the list of directors includes representatives of both firms. Mr. G. Haslam was a member of the original firm of Haslam's Company, which was purchased after the death of Sir Alfred Seale Haslam, by Mr. Jesse H. Lord and Mr. H. B. Potter, of Rochdale, both of whom continue on the Board. The only addition is Mr. G. J. Tennisen, of Wassenaar, Holland, who is the Continental representative.

A Bright Future.

The prospects of the new company are indeed very bright, and the directors entertain great hopes that the turnover and profits should increase considerably in the near future. It is interesting to record that during the past few years the combined profits show a considerable advance. In 1925-6 they were £48,279; in 1926-7, £54,449; and in 1927-8, £53,506, which gives an average of £52,078.

At the present time both works are fully employed. Profitable contracts are in hand and others in course of being arranged, and these, our representative was informed, are sufficient to keep the works employed for longer than a year. It is not very long ago since the Haslam Foundry Company, Limited, supplied machinery to the Orient Company for their new liner, "Orford," and moreover, they have installed plant on four of the new vessels belonging to the Blue Star Line. Messrs. Newton Brothers have carried out some big Government contracts, and supplied electrical power equipment for a large number of wireless stations, and for many telephone exchanges in the country.

Since the formation much activity has prevailed, with the result that the works have secured some big contracts. Additional employment is likely to be found, and our representative is informed that since the prospectus was issued contracts have been signed by the firm for £200,000 worth of machinery, some of which were in the course of negotiation when the issue was made. The contracts are for electrical and mechanical goods, and will keep the employees of both foundries fully occupied.

A Correction.

A note on the use of the side-blown converter, for the production of steel castings. Two slight mistakes have unfortunately crept into this article on page 305, column 3, para. 5. One should read "high Si," and not "high S." hematite, whilst the last paragraph should read: "The ideal plant would consist of a basic-lined open-hearth furnace" (not electric).

The Rodney Foundry Company, Limited, has removed to Deptford Green, S.E.8. The 'phone No. is New Cross 4612.

Random Shots.

To conclude my review of the Motor Show I should have stated that there were various minor accessories with some of the models mentioned; for example, the Sardine Tin is complete with tin opener and the Cocktail Shaker with lid. Most of the models are fitted with cigarette lighters and corkscrews, and the finish on them renders it unnecessary for madame to carry a pocket mirror.

* * *

There is no truth in the rumour that we are embarking on a scheme of insurance which will protect registered readers against the minor accidents of foundry life; such as stumbling over the handle of a shank, injuries to self respect on being ticked off by the foreman, wounded pride due to wasters, damage due to the presence of green in the eye, and so forth.

* * *

If our imports are to be safeguarded, why not make a start on Mrs. Aimée Semple McPherson? The Chambers of Commerce have declared the procedure much too complicated. Not so Semple as it sounds, in fact.

* * *

It was characteristically like salesmen to entertain the President of the Board of Education on the formation of his Committee to deal with education for salesmanship. But I cannot swallow Mr. F. W. Goodenough's statement that better salesmanship will solve the unemployment problem.

* * *

Some critics of the salesman will say that, in these days, nothing is too bad for successful salesmen to sell, and to sell regularly and at a good profit; that what a salesman says three times is, of course, the truth. And when it is reiterated not three but three million times it becomes heresy to deny it.

* * *

When making a choice, salesmanship will help to decide, as between gas and electricity, for instance, or between a fur coat and a diamond necklace. But can it in the aggregate increase the demand? It may help us to some of our lost export markets, but so far as the home market is concerned salesmanship can only coax money out of our pockets when we have plenty, and when we are indifferent whether we spend it or not; and that does not apply to most of us. We have to limit our demands on our incomes, not go out of our way to be responsive subjects to scientific salesmanship. Salesmanship may help one firm to get orders at the expense of another, but that does not solve the unemployment problem, it merely redistributes the unemployed.

* * *

Did you hear of the clergyman whose claim to fame was that he could never answer a conundrum? Two friends arranged to prove him wrong by asking him the resemblance between two things chosen at random so that there could be no connection whatsoever between them, and hence no reply. One asked him, "What is the resemblance between a ghost and a bun?" He immediately answered, "They are both fancy bred."

* * *

New Alphabet for Ironfounders.

(Continued.)

The pressure on this column is so great that the alphabet progresses slowly. We have, you may recall, got as far as L.

M. stands for Moulding, a glorious game:
It's like making mud-pies in all but the name.
N. is the Nightshift, that overworked band,
Who thro' all their troubles stay perfectly bland.
O is for Oven: the cores there we bake:
The missus no doubt covets it for the cake.
P is for Pig, of a non-grunting kind,
Though connected with Sows in the past, you will find.

Marksman.

British Cast Iron Research Association.

Seventh Annual Report.

Cast Iron—A Range of Alloys.

The seventh annual report, for the year ending June 30, 1928, stresses the growing influence of the Association in determining the current attitude to cast iron and the founding industry. At one time considered as a Cinderella material, used because it was cheap, with properties of no particular importance as long as it performed its main function of filling the mould, it is now generally recognised as a highly important and complex metallurgical material, the use of which is governed by its intrinsic properties, which are governed in turn by constitution. Engineering opinion, in fact, is beginning to consider cast iron in its true light, not as a material, but as a range of materials capable of indefinite modification to suit particular service conditions.

Reference has been made in previous reports to metallurgical developments in cast iron on the Continent and in the United States. There is no doubt that the establishment of the Cast Iron Research Association has been followed with interest in these countries, and its programme examined. There are signs that recent movements in both continents towards the promotion of research by the united action of manufacturers have been definitely inspired by the existence of this Association. It is, therefore, particularly necessary that the Association should grow in the confidence of the industry until it ultimately becomes fully representative. The Association is still not able to do one quarter of what could be done in the industry if adequate financial support were forthcoming. There are signs, however, that the set-back caused by the coal dispute is temporary, and that the rate of progress which obtained prior to this is being renewed.

Although there has not been a large increase this year in subscription income, the Council is able to record that in the year under review the subscription income has been the highest in the history of the Association.

The first steps have been taken towards the acquisition of a melting plant belonging to the Association. By courtesy of the directors of Lee, Howl & Company, Limited, space has been provided in their works at Tipton for a crucible furnace kindly donated by the Morgan Crucible Company, and equipped with a fan and motor given by James Keith Blackman & Company, Limited. The Council is indebted to Lee, Howl & Company, Limited, not merely for their interest in providing the accommodation, but for much additional assistance, without which the running of the furnace would be impossible. It is hoped at a later date to arrange for the installation of a cupola to the Association's design, but this is held up pending the completion of certain cupola experiments referred to more fully below.

The second main feature of the year's work has been the great extension of experimental work in members' works on a practical scale. The Association has since its foundation recognised the necessity for putting its conclusions into practice with the least possible delay, and in order to do this invites inquiries from members who desire to raise any matter connected with foundry practice. The replies enable the latest scientific information at the disposal of the Association to be put into practicable form, and this partakes of the nature of industrial development, which is essential to the successful application of scientific results. In addition to this, however, large scale experiments have been commenced in members' works. Two of these concern the cupola—the first, dealing with the influence of cupola design and air supply upon operation, is being carried out by courtesy of Mr. G. Pate, O.B.E., J.P., at the works of the Carron Company, Carron, and the second, a series of experiments on the influence of coke on quality and quantity of metal, at the works of Smith, Patterson & Company, Limited, Blaydon-on-Tyne, by courtesy of Mr. R. O. Patterson. This last-mentioned series of tests is being done in conjunction with the Northern Coke Research Committee. A third series of tests concerns the composition of irons used in light castings, and is being carried out at the works of Smith & Wellstood, Limited, Bonnybridge, by courtesy of Mr. G. A. Ure, J.P.

The remaining development of interest is the extension of the policy of holding members' meetings. In the last financial year the experiment was tried of holding private meetings of members in a few industrial centres for the purpose of putting before the members some features of the Association's work for discussion and criticism. It was hoped in this way to keep members closely in touch with the work, to provide a means of discussion, and to get over the difficulties found by many members in reading and making adequate use of purely technical reports. This experiment was so well received by members that in the year under review two further series of meetings have been held in each of ten industrial centres chosen with regard to the geographical distribution of members. These are London, Birmingham, Swansea, Manchester, Sheffield, Leeds, Newcastle, Glasgow, Falkirk and Ipswich. These meetings involve a considerable amount of time on the part of the Director and Consultant, but from the discussions and from comments received from members it is believed that they serve a highly useful purpose, and should be continued. It is hoped to arrange at least three series during the coming year, to develop the meetings, to extend the subject matter, and to arrange for other members of the staff to take part in them.

Finance.

There is an excess of expenditure over income for the year of £140; whilst two years ago, when the Association possessed nothing beyond office furniture and the library, it became necessary to expend the sum of £1,200 in connection with the new premises and the requisite equipment and apparatus. During the year 1926-1927 the sum of £1,003 was so spent, and the £140 referred to represents part of the remainder of this allotted sum, thus bringing up the total to within £57 of the anticipated figure. The excess expenditure has, therefore, been incurred in accordance with the predetermined plan. Apart from this, no less than £262 from the income has been applied to writing off assets: the whole of the amount at which the books and periodicals in the library stand in the balance sheet, together with part of the amount for office equipment and furniture. The Association's assets now stand in the books at the sum of £480. In effect, therefore, the expenditure for the year is well within the actual income. During the year ending June 30, 1926, the total expenditure on accommodation was £816, and last year, in which the removal was effected, the total was £773. During the year under review the total is £596.

At any given time the Association has in hand barely two months' expenditure. This is an undesirably small margin, and is due in part to the necessity for finding, out of income, money for capital extensions, referred to above in connection with the new building. Trade conditions have prevented any appeal to members for assistance in this connection. The necessity for finding expenditure for apparatus and equipment out of income is naturally a serious handicap.

Membership.

The subscribing membership of the Association in all classes is 298, of which the number of ordinary and trade members is 227.

Council.

Mr. H. B. Weeks, F.I.C., has again acted as Chairman of Council and of the Research Committee, and has earned the warmest thanks of the members for the time and energy he gives to the Association's affairs. Mr. F. J. Cook, Mr. J. T. Goodwin, and Mr. Oliver Stubbs have served as vice-chairmen. The Council regrets the serious illness of Mr. Oliver Stubbs for a large part of the year, and trusts that he may be speedily restored to health. The Council congratulates Mr. Goodwin on the successful completion of his year of office as President of the Institute of British Foundrymen. Mr. W. B. Parker, F.I.C., has acted as Chairman of the Publications Committee, which during the year appointed an Education Sub-committee. Since the close of the year this body has been formally given the rank of a committee of the Council.

A striking feature of the year's work has been the continued success of the sub-committee system. The research programme supervised by the Research Committee is divided up, and seven sub-committees are responsible for particular sections of it. During the year the number of meetings and attendances at sub-committee meetings has greatly increased, and it is by the sub-committees that the front line work of the Association is being done. The general success of the committee system serves to emphasise the soundness of the plan of re-organisation adopted in 1924 and recorded in the annual report for that year.

During the year six meetings of the Council have been held, with an average attendance of fourteen. Of the Research Committee eight meetings have been held, with an average attendance of twelve. Of Research Sub-committees twenty-three meetings have in addition been held, the average attendance being eight. Five meetings of the Publications Committee have taken place, with an average attendance of eight, and three meetings of special committees. During the year also the Scottish Committee has held two meetings, with an average attendance of ten. A complete list of committees is given in Appendix I.

In addition to these formal meetings the Director and Consultant take advantage of opportunities of keeping in touch with members of Council during visits to various industrial centres in connection with members' meetings referred to above.

Council and committee meetings have been held in London, Birmingham, Sheffield and Falkirk, and the thanks of the Association are due to the Iron and Steel Institute for the loan of rooms for meetings.

Internal Organisation.

During the year Mr. G. Murray, chemist to the Association, resigned, and is succeeded by Mr. C. Rowley.

Research Work.

Corrosion-resisting Cast Iron.—There is considerable need for a corrosion-resisting iron of good mechanical properties for engineering applications where ordinary cast iron has insufficient resistance. After a series of corrosion tests on a wide variety of engineering irons, it was established that the improvement in corrosion-resisting properties to be obtained by making practicable alterations to ordinary compositions was slight, and it was necessary to consider a radical departure from existing composition, preferably to examine irons rendered austenitic by the addition of special elements. A series of corrosion tests was therefore made on irons containing nickel originally made in connection with the nickel iron investigation, and it was decided as a next step to consider a series containing chromium and/or copper. At this point news was received from the International Nickel Company of the development of an iron containing nickel and copper in the proportions usually found in Monel metal, and corrosion tests were made on this composition with very satisfactory results. Preferred compositions and test results have been communicated to members. It is well known that no single corrosion test will suffice to determine the suitability of a resisting material under all conditions, and a test under service conditions is the only guide. The information was therefore placed before members so that they might pursue the matter further if desired. The additional elements naturally increase the cost considerably, but this still remains well below the cost of any alternative material, ferrous or non-ferrous, which might have to be used, and at the present time no cheaper method is available of rendering iron of corrosion-resisting composition. Even so, this alloy is, like stainless steel, not corrosion proof, and under some service conditions is markedly corroded. Under other conditions,

however, it resists much better than ordinary engineering iron.

Moulding Sands.—The basic work being carried out at the University of Sheffield of testing particular deposits of moulding sands has been extended, and tests have been completed on Southampton moulding sands and on Scottish moulding sands. In addition to the chemical analysis, permeabilities and mechanical strengths over a range of moisture contents and degrees of ramming, the refractoriness of clay and sand have been taken on the whole series.

Two tests have been chosen as suitable for regular foundry control—permeability and compression strength—and apparatus for the conduct of these tests has been made; full details will be put before members at an early date. Experiments have also been carried out on the influence of the sand condition on the surface of the casting. A start has been made on refractory materials for cupola linings.

Heat-resisting Irons.—The study of this complex question has been continued, and some results of extreme interest have been obtained on unusual but practicable mixtures. The Association has co-operated with the Fuel Research Board in the question of design and composition of retorts for low-temperature carbonisation, and these retorts are now in service at the Greenwich Fuel Research Station. It is understood that the retorts show a large increase in through-put of coke compared with that obtained on the retorts which were displaced, but it is, of course, too early to judge the improvement in service life.

Following the second report of the Heterogeneity Committee of the Iron and Steel Institute, which dealt with ingot moulds and their influence on the properties of steel, the Chairman, Dr. Hatfield, suggested that the Association should supply data on the fundamental properties of ingot mould irons. A meeting attended by ingot mould makers in the Sheffield area was held, and the support of all ingot mould makers is being sought for a programme of investigation.

Malleable Cast Iron.—Following the determination of the influence of manganese, sulphur, and total carbon on the properties of white heart malleable, the whole of the year has been occupied in a lengthy investigation on the influence of silicon, together with total carbon. This is probably the most complete investigation made into the influence of composition on the properties of white heart malleable, and is now approaching completion. In addition a number of auxiliary points have been dealt with.

Light Castings Irons.—A series of melts of pig-irons suitable for light castings has been made, and test results compared as a preliminary to the systematic determination of the influence of varying silicon, manganese, and phosphorus. The silicon range has been completed.

Alloy Cast Iron.—The investigation on the influence of nickel has been continued during the year by Dr. A. B. Everest in the Metallurgical Department of the University of Birmingham, under the supervision of Professor D. Hansen. The Association co-operates fully in this work, which is supervised by the Nickel Sub-Committee. The influence of nickel has been established, and a series of melts on a practical scale, both from crucible and cupola, has been made at the works of the Midland Motor Cylinder Company, Limited, by the courtesy of Mr. P. Pritchard, and Belliss & Morcom, Limited, by courtesy of Mr. F. O. Everard. Service tests on automobile cylinders with and without nickel are in active progress.

Cupola Tests.—Following the visit to France and Belgium, reported last year, when the Director and Consultant saw a new design of cupola at work, this design was tested at the works of Cameron & Roberton, Limited, Kirkintilloch, by courtesy of Mr. John Cameron, J.P. The results of this test will shortly be available to members.

It is impossible for many foundries with existing cupola melting conditions to take advantage of recommendations for melting special mixtures, and the Association has continued its work in advising members desiring to re-model their cupolas on modern lines. The results of the design worked out by the Consultant have been eminently satisfactory, and the Association therefore gratefully accepted an offer on the part of Mr. G. Pate, O.B.E., J.P., of the Carron Company, to install a cupola to the Association's design, which would provide more definite and more sensitive control than has yet been possible. The design was duly worked out by the Consultant, and installed by the Carron Company, and experiments have proceeded, the aim being to determine the fundamental principles of cupola operation with respect to the distribution, volume, and pressure of air, coke consumption, etc. The progress is naturally slow, for the cupola is used on commercial work, and it is not possible to risk the production of waster castings. At the same time it is necessary to produce castings very thin in section at a high temperature for successful pouring, and this has been done with marked success for a very low coke consumption. The experience gained will inevitably influence cupola recommendations in the future.

The Northern Coke Research Committee is engaged in the study of the properties and structure of metallurgical coke required for particular kinds of service. The Association co-operates in connection with cupola coke, and by arrangement with Smith, Patterson & Company, Limited, Blaydon-on-Tyne, by courtesy of Mr. R. O. Patterson, a series of melts have been made with varying types of coke with very close observation of consumption, temperatures, etc. This series probably forms the most complete series of cupola tests yet made.

The Influence of Manganese.—The Senior Metallurgist is personally conducting a series of investigations with the object of correlating composition with properties, of determining the influence of rate of cooling, and generally of explaining a number of anomalies which at present handicap the metallurgist in dealing with cast iron. The first result of this has been a preparation of a report on the influence of manganese on cast iron, which definitely reconciles the many conflicting opinions which have hitherto been held with regard to this influence, and the report will be of value in many practical ways where the influence of manganese is of importance.

The Testing of Cast Iron and the Design of Cast-Iron Structures.—With a view to providing engineers with means for ascertaining the strength of cast iron in different sections, the Association has developed the transverse test on the round bar by determining the modulus of rupture over a series of diameters for the same mixture. The curve obtained shows the variation in strength of iron with section, and when determined for several mixtures provides a useful chart for the designer. With the assistance of various members, several series of bars have been made and tested during the year. Work has also been done on the practicability of the shear test for cast iron, and its relation to the tensile test.

Recommended Methods of Analysis.—With a view to eliminating causes of discrepancies between analyses of the same material by different laboratories, the Association has prepared recommended methods of analysis for the constituents of cast iron, for the proximate analysis of blackings and plumbagos, coal and coke dusts, and for the sampling of sand and coke. It is hoped to formulate a complete set of recommended methods to cover the ordinary operations of a foundry laboratory.

The Future.

According to present arrangements with the Department of Scientific and Industrial Research, during the year under review the Association has enjoyed a grant of £1 for £1 in respect of subscription income. This will also be received for the year 1928-1929, following which the grant is to be reduced to 10s. in the £1. This will mean an immediate reduction in income of over £2,000 per annum, and it is not at present possible to see how that additional sum can be obtained. This reduction in income would, therefore, seriously handicap the Association's work.

Furthermore, under present arrangements, the grant would cease completely in 1931, the whole of the million fund set aside by Parliament to aid Research Associations, being then exhausted. It was clear two years ago that there is little likelihood of Research Associations as a whole being able to support themselves entirely after this date, and the Conference of Research Associations instructed its Standing Committee, of which the Director is a member, to consider the matter and take appropriate steps. A petition was prepared, duly signed by the whole of the Research Associations, and subsequently presented to Earl Balfour, as President of the Privy Council, which is responsible to the Cabinet for the Department of Scientific and Industrial Research. The petition was presented by a small deputation, led by Sir James Hinchliffe, representing the textile trades, and seconded by Sir Philip Nash, Pesident of our Association.

The deputation stressed the national character and importance of the work done, and that the benefits of research are felt by the consumer as well as the manufacturer.

After due consideration Lord Balfour announced the Government's decision, which is that a further offer of grant on the £1 for £1 basis will be given to Research Associations for a period of a further five years after 1931, and there will be power to repeat this for an additional five years, making a further ten years in all. This grant, however, will not be upon the present basis. It is intended that each Association must be self-supporting to the extent of having a certain minimum subscription income from the industry, and the grant will only be paid on income received in excess of this figure. It is clear that the prospective income of any Association under this scheme will depend entirely on the minimum to be fixed, and this will be done by the Advisory Council to the Department of Scientific and Industrial Research. We are assured that each industry will be taken on its merits, with a sympathetic regard to the whole of the circumstances.

Supposing the minimum for an Association were fixed at £2,000 per annum, only the additional £2,000 on an annual subscription income of £4,000 would be grant earning, so that the total income would be £6,000 per annum. On the other hand, if the minimum was fixed at £1,000 the total income on a subscription income of £4,000 would be £7,000 per annum.

At this stage it can be stated that the official announcement will ensure continuity for the Research Association, and the granting of this important concession is one which the Association can view with gratification, for the officers of the Association took a prominent part in the negotiations which led to the petition to Lord Balfour, and the President played a leading part in the interview itself.

Conclusion.

The Council records with satisfaction the steady increase in the work and influence of the Association, and in particular the resumption of progress in subscription income during the year. The relatively unorganised condition of the foundry trade renders necessary the increase of membership by the lengthy process of individual approach. As the work of the Association is becoming more generally known, this difficulty is being in part removed, and the general support of the trade would suffice to put the Association beyond any fear of financial restriction. The report is signed by Mr. H. B. Weeks, the Chairman of Council, and Mr. J. G. Pearce, its Director and Secretary.

Derby Works Inspection.

At the invitation of Sir Henry Fowler, the Derby members of the Association of Engineering and Shipbuilding Draughtsmen, numbering about 120, last Saturday visited the locomotive works of the L.M.S. Railway, when a full afternoon of technical interest was enjoyed. In the course of a tour round the buildings a considerable amount of new and rebuilding work in progress and the ingenious methods employed to ensure expeditious handling were noted.

L.M.S. Presentation.

On his retirement, after 37 years' service in the engineers' department of the L.M.S.R., Mr. William Watkins, of Derby, has been presented with a wallet of Treasury notes by his colleagues. In making the presentation in the branch room, Friargate, Mr. Stockdale, works inspector, wished the recipient joy in his retirement.

The Heat Treatment and Volume Changes of Grey Cast Irons between 15 deg. and 600 deg. C.

By J. W. Donaldson, D.Sc., A.I.C.

(*Continued from page* 303.)

Microscopic Examination.

An extensive micro-examination was made on sections taken from all the irons at various stages during their heat treatment, involving the preparation and examination of a few hundred micro-sections. This micro-examination confirmed in general the results obtained by the analytical and physical methods (tensile testing and hardness determination) already dealt with. To illustrate the changes taking place in the structure, photographs were taken of a number of the irons after the 200 hours' heat treatment at 550 deg. C.

The low total-carbon iron C1 in its cast condition has a typical pearlitic structure with finely-divided graphite and a small amount of free ferrite. The other irons of the carbon series show a somewhat similar structure, except as to the relative proportions of graphite and ferrite, which both increase slightly as the total carbon increases. Fig. 10 shows the iron C1 after 200 hours' heat treatment at 550 deg. C., when the combined carbon has decomposed by 31 per cent., and Fig. 11 the iron C3 after similar heat treatment had produced a decomposition of approximately 62 per cent. In the first case the pearlite has lost its lamellar appearance, and appears to be in a state of disintegration, and in the latter case this disintegration is more pronounced, the amount of pearlite being less, and areas of free ferrite occurring. In both irons the change in the pearlite has been accompanied by increase in the size of the graphite plates and by partial oxidation of the iron in the vicinity of the graphite, more noticeable in the case of C3 iron with the higher carbon content.

The four manganese irons have a microstructure of lamellar pearlite, finely-divided graphite, a little free ferrite, and patches of the phosphide eutectic. The irons containing 0.97 and 2.43 per cent. manganese, M2 and M4, after heat treatment at 550 deg. C., when the combined carbon had decomposed by approximately 82 and 66 per cent., were photographed and are given in Figs. 12 and 13. In the former the pearlite is more or less completely decomposed, only small areas occurring, the ferrite has increased very considerably, and the graphite plates show a marked increase in size; while in the latter, although the pearlite shows considerable change, the areas are larger, and the graphite flakes do not appear to be quite so large.

The microstructure of the phosphorus irons as cast shows pearlite, finely-divided graphite, a little ferrite, and in P3 and P4 there are areas of phosphide eutectic, particularly in the latter. The low-phosphorus iron P1, 0.20 per cent. phosphorus, shows an 86.1 per cent. combined carbon decomposition after heat treatment at 550 deg. C., and this is reflected in the microstructure, Fig. 14, where the pearlite is largely disintegrated, the ferrite increased, and the graphite swollen. Slightly more pearlite is apparent in the 0.70 per cent. phosphorus iron after a similar heat treatment, Fig. 12, and there is little apparent difference in the graphite, but more oxidation of iron.

The most noticeable changes, however, are observed in the irons of the silicon series. The two lower silicon irons have a uniform pearlitic structure with graphite flakes distributed throughout, while in S8, although the structure is mainly pearlitic, there are evidences of free ferrite and areas of the phosphide eutectic, and in the 2.19 per cent. silicon iron, S10, the micro-structure consists of pearlite, ferrite, graphite, and phosphide eutectic. After 200 hours' heat treatment at 550 deg. C., the structure of the two lower silicon irons, 0.65 and 1.05 per cent. silicon, which have a carbide decomposition of 19.8 and 24.1 per cent., still retain their pearlite structure, Figs. 15 and 16, although there is a distinct change in the nature of the pearlite. It appears less compact, and has a distinctly weaker appearance, especially in the higher silicon iron, where there are distinct ferrite areas formed. In both irons, although the graphite plates show an increase, particularly in the former, in size, there is little evidence of oxidation.

The 1.10 per cent. silicon iron, whose combined carbon decomposed by 32.9 per cent. after a similar treatment, shows a similar change, Fig. 17, although in this case the pearlite has lost its lamellar appearance and appears broken up and disintegrated. The 1.24 per cent. silicon iron, which decomposed to the extent of 62 per cent., shows a change corresponding to this decomposition in its structure, Fig. 11, where the amount of pearlite is less, and large ferrite areas have appeared. A similar structure is visible in the 1.48 per cent. silicon, Fig. 12, excepting that there is less disintegrated pearlite and more free ferrite corresponding to the increase combined carbon decomposition of 82 per cent. In both irons the bulkier graphite is largely replaced by iron oxide. Lastly, in the high silicon iron, 2.19 per cent. silicon, the amount of pearlite visible, after a 550 deg. heat treatment, is practically nil, Fig. 18. The structure consists of coarse, swollen, graphite flakes which show considerable oxidation and patches of undecomposed phosphide eutectic.

Conclusions.

The conclusions resulting from the foregoing tests may be summarised as follows:—

(1) Heat treatment of grey cast iron at temperatures below the critical range produces changes in the iron which affect the strength and hardness.

(2) These changes are due to decomposition of the combined carbon and are influenced by the temperature of treatment, the duration of treatment, and the composition of the iron.

(3) The duration of treatment affects the amount of change, and for the various temperatures and for the different irons, an equilibrium value is attained for the 200 hours' period of heating.

(4) As the total carbon content of grey cast iron is increased from 2.71 to 3.51 per cent., the stability of the combined carbon and consequently the heat-resisting properties are decreased, a decided change taking place between 2.71 and 3.08 per cent.

(5) Increase of manganese from 0.52 to 2.43 per cent. produces a uniform increase in the heat-resisting properties.

(6) Increase of phosphorus from 0.20 to 1.06 per cent. produces a slight but uniform increase in the heat-resisting properties.

(7) The influence of silicon is to produce a marked influence on the heat-resisting properties. With less than 1.10 per cent. silicon, great stability is attained, which increases uniformly as the silicon decreases to 0.65 per cent. Over 1.17 per cent. silicon decomposition of combined carbon is considerable, and increases as the silicon content increases. There appears to be a critical composition of silicon between 1.10 and 1.17 per cent., so far as combined carbon decomposition is concerned.

Part II. Volume Changes Between 15 and 600 deg. C.

It has been stated by various authors that no growth takes place unless cast iron is heated through and above the critical range, but it is well known, however, that volume changes take place at temperatures considerably below 650 deg. C. Carpenter mentions a case where a turbine casing grew 7 per cent., and it is well known to manufacturers and users of internal-combustion engines that such parts as cast-iron pistons and cylinders are liable to volume changes. Systematic work has also been done by Campion and the author,[1] and by Higgins[23] on this subject. In the former case, three commercial cast irons and three manganese cast irons were heated to 450 and 550 deg. C. respectively for 20 to 25 heatings in an atmosphere of coal gas, when a considerable amount of growth was obtained, being as high as 1.6 per cent. in one iron. In the latter case two series of cast irons, containing 1.5 per cent. silicon, in the first series of which the phosphorus was low and the manganese varied, and in the second series the manganese was low and the phosphorus varied, were subjected to 21 heats to 600 deg. C., being soaked for three hours at that temperature. As a result of these investigations, Higgins states that in the manganese series growth is due to oxidation and graphitisation, and an increase of the manganese stabilises the iron against changes in the expansion. In the phosphorus series, increase in phosphorus delays growth, the phosphorus protecting the iron from oxidation. Phosphorus also increases the uniformity of the coefficient of expansion.

Method of Testing.

In carrying out growth and volume change tests, the various investigators have adopted one of two methods. Bars of the irons were either heated and cooled in a furnace, and the increase in the length and diameter of the bars measured after each successive heat or series of heats, or a dilatometer method was used, where the specimens were successively heated and cooled and their increase in length measured through the temperature range. The method used in the present series of experiments consisted in heating two bars of each iron, accurately machined to 6 in. in length and 1 in. in dia., in an electric-resistance furnace daily for a period of eight hours to a temperature of 550 deg. C., allowing to cool overnight and reheating the following day. After five heatings, the bars were removed and accurately measured by means of a Whitworth measuring machine reading to hundred thousandths of an inch. The average measurements obtained were then used to calculate the volume increases.

Cast Irons Used.

The volume changes were carried out on the same series of irons as those used for the carbon decomposition tests, the only irons omitted being S3, S4, and S5, of the silicon series. Their compositions are given in Tables I to IV.

Consideration of Results.

The results are represented graphically in Figs. 19 to 22. They are considered in the different series to which they belong.

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Carbon Series.

From Fig. 19 it is seen that volume changes or growth takes place with all the irons, but that the amount varies with the total carbon content, increasing as the carbon increases. The iron containing 2.71 per cent. carbon shows a slight increase in volume after five heatings, which increase is continued after 10 heatings, after which the increase is practically nil. In the same iron the bulk of the carbon decomposition at a similar temperature, 550 deg. C., takes place during the first 80 hours' heating, corresponding to the above 10 heatings, and attains an equilibrium value after 120 hours, corresponding to 15 volume heatings, Fig. 1. In the 3.08 per cent, carbon iron, the volume increases uniformly for the first 15 heatings, after which it becomes practically constant, and the amount of combined carbon decomposition which takes place in this iron, Fig. 1, does so in the same period of time. The 3.30 per cent. carbon iron, which shows a slightly greater volume increase, assumes its maximum increase after a similar number of heatings, although the bulk of the increase appears to take place during the 5th and 10th heatings, whereas the iron with the highest total carbon, 3.51 per cent., increases in volume steadily for 15 heatings, after which there is a slight increase to 20 heatings, when there is maximum increase of 0.17 per cent. Reference to the carbon decomposition curves, Fig. 1, shows that equilibrium conditions for these two irons are more or less complete after 120 hours' heating, corresponding to 15 growth or volume heatings.

Micro-sections were taken from the four irons, not only after the heatings were complete, but also from bars subjected to the same heat treatment and examined after each five hours' heating, in order to determine changes in the structure. These showed a breaking down in the pearlite due to combined carbon decomposition and an increase or swelling in the size of the graphite flakes during the earlier heats, results which were in accordance with those previously obtained by analysis. In the three higher carbon irons there was oxidation of the iron in the vicinity of the graphite plates and partial replacement of the graphite by this oxide. This oxidation was visible after five heatings and increases as the heatings increased. The lower carbon iron only showed oxidation after 15 heatings. The micro-photographs shown in Figs. 10 and 11, already referred to, represent the general nature of the changes produced in the irons containing 2.71 and 3.08 per cent. total carbon, after 25 heatings or 200 hours' heat treatment at 550 deg. C., and show the decomposed pearlite, free ferrite, bulkier graphite, and oxidation which has taken place.

These volume tests, analysis, and micro-examinations indicate that the primary cause of growth in these irons, at the temperature of treatment, is the breaking down of the pearlite due to decomposition of the combined carbon forming free ferrite and graphite, and the increase in size or swelling of the graphite plates. Oxidation of the iron in the vicinity of the graphite plates, which follows on these changes taking place, is due to air penetrating along the bulkier graphite flakes and causing oxidation, the permeability of air in cast iron up to 600 deg. C. having been demonstrated by Kikuta. This oxidation accentuates the growth caused by the carbon change, but appears to be secondary to it. The amount of growth would appear to be related to the amount of carbon decomposition, but results obtained with the irons of the other series show this is not so. It is more probably due to the initial quantity of graphite present in these irons, which ranges from 1.84 to 2.86 per cent. The graphite flakes increase in dimensions due to heating, and the more graphite present the greater will be the aggregate increase. More graphite also facilitates the penetration of more air with consequently more oxidation.

Manganese Series.

Conclusions of a somewhat similar nature can be drawn from consideration of the volume changes of this series of irons (Fig. 20), although increasing manganese content affects cast iron different from increasing carbon content, there being a slight increase in growth as the manganese increases.

The curves for the two lower manganese irons, 0.52 and 0.97 per cent. manganese, are similar except for the first 15 heatings, due to the former iron showing a slower rate of growth than the latter. The ultimate volume change is the same for both, being 0.13 per cent. The two higher irons, 1.87 and 2.43 per cent. manganese, show practically the same volume changes, which is slightly higher, being approximately 0.15 per cent. Reference back to the carbon decomposition curves, obtained by analysis, Fig. 2, shows that the curves for the two lower irons are very similar, as are also the curves for the two higher irons of the series. The times for producing equilibrium conditions are respectively 120, 80, 120 and 120 hours, agreeing with the corresponding periods of attaining maximum volume of 15, 10, 15, and 15 heatings.

The micro-examination of all the irons, carried out in a similar manner to those of the carbon series, show and confirm the relationship between the diminution of the combined carbon and the breaking down of the pearlite, with formation of ferrite and increase in the size of the graphite flakes at different periods of heating. The micro-photographs, Figs. 12 and 13, showing the 0.97 per cent. manganese iron after treatment for 200 hours at 550 deg. C., and the 2.43 per cent. manganese after similar treatment, illustrate the general structural conditions obtained. The graphite plates show increase in size, the pearlite shows decomposition, and there is oxidation of the iron in the vicinity of the graphite and replacement of the graphite by this oxide. This oxidation was seen to a small degree, but particularly in the 0.97 per cent. manganese iron after five heatings. Generally, however, with the exception of the relative amounts of decomposed pearlite there it little to distinguish between the four irons as regards graphite and oxidation.

The initial cause of growth and the gradual increase to a maximum volume in these four irons appears to be principally due to the decomposition of the combined carbon and the increase in the size of the graphite plates, followed by oxidation. The magnitude of the volume changes are not, however, in proportion to the amount of decomposition as already indicated when dealing with the carbon series of irons, otherwise growth would be retarded with increasing manganese content, which is not the case, the two higher manganese irons showing a slight but definite increase in volume. There must be some other factor in promoting growth. In the case of the carbon series this factor is probably the initial amount of graphite present in the iron, but the same cannot be said of the present series, as the initial graphite contents of the irons are practically the same. It is dependent in some way on the manganese and is probably due to oxidation of this element. Micro-examination of the present series of irons did not indicate additional oxidation of the higher manganese irons, but as the amount of decomposition in these irons was approximately 70 per cent., and as the decomposition products would contain more manganese than in the case of the lower irons, and as manganese is a highly oxidisible element, it can be assumed that the slight additional growth is due to oxidation of the manganese.

Phosphorus Series.

Considering the volume changes of this series of irons (Fig. 21), together with the carbon decomposition results for the same irons given in Fig. 3, the resemblance between the volume curves and the combined carbon change curves is again noticeable. The larger proportion of the growth takes place in all the irons during the first five heatings corresponding to the greater part of the carbon decomposition, while maximum growth is attained aften ten heatings except in the case of the low phosphorus iron where fifteen heatings are required. The amount of growth, 0.15 per cent. for the 0.20 and 0.41 per cent. phosphorus irons, decreases to 0.13 and 0.11 per cent. as the phosphorus content is increased to 0.70 and 1.06 per cent.

A micro-examination of sections from all the irons taken after the various heating periods shows the structural changes produced to be more or less in agreement with the volume and composition changes. The disintegration of the pearlite is accompanied by increase in the size of graphite flakes which appear larger in the 0.20 per cent. phosphorus iron, and is followed by oxidation in all the irons after the first five heatings, oxidation, however, being less marked in the low phosphorus iron. Fig. 14 shows the structural appearance of this iron after treatment as compared with the higher phosphorus iron—0.70 per cent. phosphorus, after similar treatment, Fig. 12—and shows the relative sizes of the graphite flakes and the amount of oxidation.

The phenomena accompanying volume changes in the two previous series of irons are also present in these irons, decomposition of pearlite with increase in the size of the graphite flakes, followed by oxidation of the iron in the vicinity of the graphite. The changes here appear to be directly connected with the amount of combined carbon decomposition, the higher phosphorus irons containing the more stable iron-carbon-phosphide eutectic showing the least growth. There is no other apparent cause for this behaviour of the high phosphorus irons; for, although the 0.20 per cent. phosphorus irons show larger and coarser graphite after growth, it is difficult to imagine that the absence of phosphorus has produced this effect. Higgins in his recent investigations on the growth of phosphorus irons containing 1.3 to 4.2 per cent. phosphorus at temperatures below 600 deg. C., not only states that increase in phosphorus delays growth, but also that phosphorus protects iron from oxidation. This is not visible, however, in the irons of the present series, but is actually the reverse, the iron containing 0.20 per cent. phosphorus showing less oxidation than the others.

Silicon Series.

The volume tests on the silicon series of irons, the results of which are given in Table XVIII, give curves, Fig. 22, which are similar and also different from those obtained in the former series of irons. The similarity is in the irons containing 1.5 per cent. and less of silicon, and the difference in the two higher silicon irons which show a marked increase in volume, growth continuing after 25 heatings, more especially with the 2.19 per cent. silicon iron.

The two lower silicon irons, 0.65 and 1.05 per cent. silicon, show a small and similar volume change of 0.06 per cent., this being attained after ten heatings corresponding to the time required to produce equilibrium conditions in the combined carbon decomposition of these two irons. The micro-examinations of these irons show a slight increase in the size of the graphite flakes in the former iron, but little change in the case of the latter. No oxidation, however, is visible in the case of the first iron, but there are slight evidences of it in the second, Figs. 15 to 16. The volume changes in these irons would appear to be entirely due to the carbon changes which have taken place.

The next three irons of this series examined for growth are really two, so far as the silicon content is concerned, the two higher irons having a similar silicon but different phosphorus content, and have already been considered with the phosphorus series. Considering the three irons, however, from the silicon aspect, it is seen that increased silicon produces increased volume changes, the respective increases being 0.11, 0.15 and 0.18 per cent. The distinct increases in volume between the 1.05 and 1.24 per cent. silicon irons corresponds with the large increase in carbon decomposition from 24.1 to 62 per cent. which occurs in these irons, the latter iron showing more oxidation than the former, Fig. 11. The further increase in volume from 0.11 to 0.15 per cent. with increase in silicon from 1.24 to 1.48 per cent. is due to the further increase in decomposition and graphitisation, Fig. 5, augmented by a larger oxidation of the iron in the vicinity of the graphite plates, Fig. 12. The iron of similar silicon content, but higher phosphorus, shows the retardment of growth due to this increase in phosphorus content.

The growth curve for the iron containing 1.91 per cent. silicon, 0.81 per cent. phosphorus, Fig. 22, shows an increase after each five heatings, an increase which gradually becomes less after each

heating, but is still continuing even after 25 heatings, although it appears to be approaching a maximum value. A similar continuous growth takes place with 2.19 per cent. silicon iron, although the increase in volume is slower for the earlier heats it is continuous and uniform, and shows no signs of attaining a maximum value even after 25 heatings at 550 deg. C. The growth in the first iron corresponds during its earlier heats with the carbon decomposition which takes place, but the same cannot be said of the second iron, for although in this iron carbon decomposition has taken place to the extent of 82 per cent. after 40 hours' heating, Fig. 22, growth after a corresponding period of heating is small, but it is accelerated during the following heatings. The erratic behaviour of this iron during its earlier growth tests is difficult to explain, but may possibly be due to the higher phosphorus content. Micro-examination showed that the phosphide eutectic tended to segregate, and in the bars used for the volume tests these segregated areas were rather large, hence, owing to the decomposition of the iron-carbon-phosphorus eutectic being slower, growth may have been retarded while these areas were disintegrated. It may be accepted, however, the initial volume changes in both these irons, as in the other irons, are due to the breaking up of the pearlite and the increase in the size of the graphite flakes. Decomposition, however, is in each case complete after 15 heatings, so that further growth must be due to some other factor.

The micro-examination of the various sections from these two irons shows the increase in the size of the graphite plates, after decomposition, to be larger than in the case of the irons already dealt with, and that the oxidation which begins after the first five heatings is more pronounced.

Fig. 10.—C1 Heat Treated for 200 Hours at 550 deg. C. × 540.

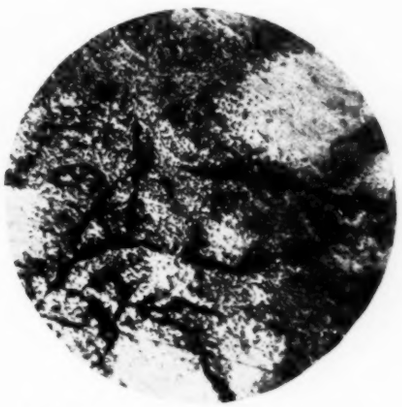


Fig. 11.—C3 and S6 Heat Treated for 200 Hours at 550 deg. C. × 540.

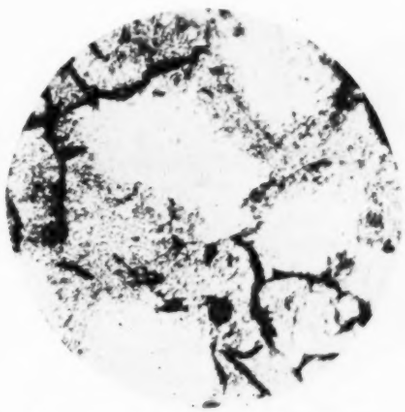


Fig. 12.—M2, P3, and S8 Heat Treated for 200 Hours at 550 deg. C. × 540.

Fig. 13.—M4 Heat Treated for 200 Hours at 550 deg. C. × 540.

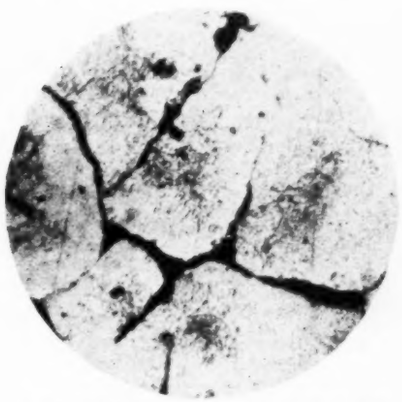


Fig. 14.—P1 Heat Treated for 200 Hours at 550 deg. C. × 540.

Fig. 15.—S1 Heat Treated for 200 Hours at 550 deg. C. × 540.

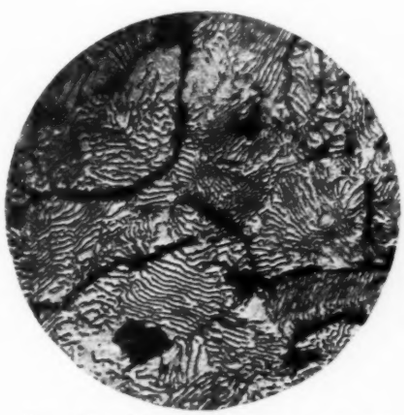


Fig. 16.—S2 Heat Treated for 200 Hours at 550 deg. C. × 540.

Fig. 17.—S4 Heat Treated for 200 Hours at 550 deg. C. × 540.

Fig. 18.—S10 Heat Treated for 200 Hours at 550 deg. C. × 540.

The micro-photograph of S 10, Fig. 18, shows the size of the graphite flakes and the extent of oxidation. It would appear, therefore, that the increased volume changes are due to the excessive oxidation produced by the presence of the silicon in the iron (silico-ferrite), causing the iron to

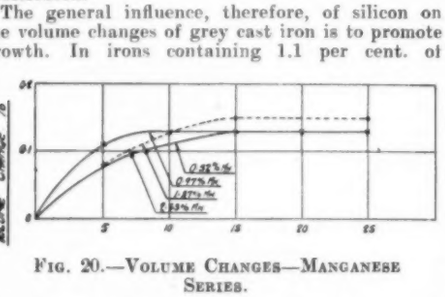


Fig. 19.—Volume Changes—Carbon Series.

oxidise more readily, and that as the silicon content increases the rate of oxidation is accelerated.

The general influence, therefore, of silicon on the volume changes of grey cast iron is to promote growth. In irons containing 1.1 per cent. of

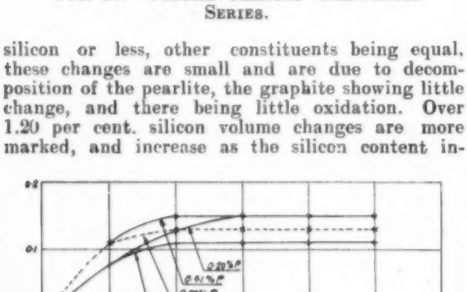


Fig. 20.—Volume Changes—Manganese Series.

silicon or less, other constituents being equal, these changes are small and are due to decomposition of the pearlite, the graphite showing little change, and there being little oxidation. Over 1.20 per cent. silicon volume changes are more marked, and increase as the silicon content in-

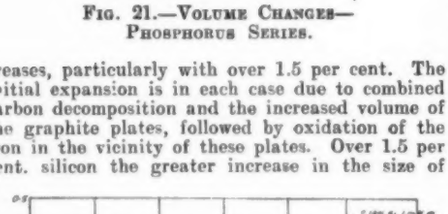


Fig. 21.—Volume Changes—Phosphorus Series.

creases, particularly with over 1.5 per cent. The initial expansion is in each case due to combined carbon decomposition and the increased volume of the graphite plates, followed by oxidation of the iron in the vicinity of these plates. Over 1.5 per cent. silicon the greater increase in the size of

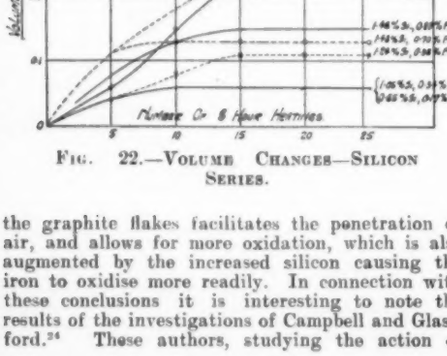


Fig. 22.—Volume Changes—Silicon Series.

the graphite flakes facilitates the penetration of air, and allows for more oxidation, which is also augmented by the increased silicon causing the iron to oxidise more readily. In connection with these conclusions it is interesting to note the results of the investigations of Campbell and Glassford.[24] These authors, studying the action of superheated steam at 425 deg. C. on grey cast iron for 30 days, found that irons containing less than 1 per cent. of silicon showed superficial oxidation and a slight penetration of oxide along the largest graphite plates, while with from 1.25 to 2.50 per cent. silicon appearances were the same, but the penetration of the oxidation appeared to grow with increase of silicon and extended in depth.

Conclusions.

An examination of the results obtained from these volume experiments suggests the following conclusions:—

(1) Grey cast irons when subjected to repeated heatings and coolings at temperatures below their critical range invariably show volume changes of varying magnitudes.

(2) The increase in volume following the first few heatings is due to the decomposition of the combined carbon, provided that decomposition is accompanied by an increase in the size of the graphite flakes. Where that increase is small, as in the case of irons containing 1.1 per cent. and less of silicon, growth is small.

(3) Where decomposition has taken place with increase in the size of the graphite flakes, air penetrates along these flakes and causes oxidation of the iron in the vicinity of the graphite, which oxide gradually replaces the graphite, and this oxidation causes further volume changes which in some irons attain a maximum after a certain number of heatings.

(4) The extent of growth is dependent in the first place on the dimensions and form of the graphite after decomposition of the combined carbon, and, secondly, on the relative amount of oxidation, factors which are controlled by the composition of the iron.

(5) In irons containing a low total carbon content, where the quantity of graphite is small and where it is in a finely divided state, volume changes are small, but where the amount of graphite increases and as it becomes larger due to increase in the total carbon these changes are increased.

(6) Increase in the manganese content causes slight increase in the growth, due to the manganese of the decomposed manganese carbide oxidising readily.

(7) Increase in phosphorus hinders volume changes, the iron-phosphorus eutectic (phosphide eutectic) decomposing slower than the pure iron carbon eutectoid (pearlite).

(8) Irons containing up to 1.1 per cent. silicon, as already indicated, show little growth, while irons containing from 1.2 to 1.5 per cent. silicon show a fair volume increase accompanied by oxidation of the iron (ferrite), which increases, however, attain a maximum after approximately 100 hours' heating at 550 deg. C. Higher percentages of silicon, 1.5 to 2.2, produce marked growth due to oxidation of the silicon and iron (silico-ferrite), which continues after 200 hours' heating, the extent and rate of growth depending on the silicon content.

The author wishes to thank Mr. James Brown, C.B.E., and the other directors of Scotts' Shipbuilding and Engineering Company, Limited, Greenock, for permission to carry out the above investigations and to publish the results obtained

In addition his thanks are due to Mr. J. Arnott, A.I.C., of G. & J. Weir, Cathcart, Glasgow; to Mr. H. J. Young, F.I.C., and Mr. C. Gresty, of the North-Eastern Marine Engineering Company, Limited, Wallsend-on-Tyne; to Mr. W. Jolley, of Metropolitan-Vickers Electrical Company, Limited, Manchester; and to Mr. J. Shaw, of the Brightside Foundry and Engineering Company, Limited, Sheffield, for their kindness in supplying the various cast irons to the author's specifications and requirements.

Nickel-Chromium Steels in Nitric-Acid Manufacture.—In a Paper read at the International Nitrogen Conference by Mr. G. Fauser the author made reference to the valuable service rendered by the nickel-chromium acid-resisting steels in the manufacture of nitric acid by pressure. According to him they have proved eminently superior to the ferro-silicon alloys originally tried out for the purpose. A composition of nickel 6 per cent., chromium 18 per cent., and carbon 0.18 per cent. was found to be specially satisfactory.

Rationalisation in Industry.

Mr. W. L. Hichens' Views.

The application of the policy of rationalisation to the basic industries of this country as a means of alleviating the prevailing depression was advocated by Mr. W. L. Hichens, chairman of Messrs. Cammell, Laird & Company, Limited, in a lecture delivered in Sheffield on Monday before the local branches of the bankers', accountants', and secretaries' organisations. Sir William H. Ellis, managing director of Messrs. John Brown & Company, Limited, presided.

Mr. Hichens asserted that there were too many firms working at the present time in relation to the demand, too many steelmakers, shipbuilders and coal-owners, and that was the root cause of the depression. The discovery of new uses for old materials was the way the prosperity of this country had been kept up in the past, but at the moment there were no striking new uses for the basic materials in sight. One of the great things they had to do was to invent new uses, and that was largely a matter for research. It was a mistake to suppose that the kind of organisation in business which was eminently adapted for an expanding period of trade was also suitable for a contracting or a stationary period. It was a very satisfactory arrangement in the old days that there should be the fullest scope for individuality, that every man of initiative and enterprise should be able to start a business of his own, and that there should be free competition among everybody in the country and the world. That was the best way of developing the new uses of raw materials then just discovered, and there was plenty of room for expansion, and no particular danger of overcrowding. Now, however, it appeared that markets were contracting, so that we had to ask ourselves whether the same freedom of individual initiative, the same organisation based on continual expansion, would do to-day. He submitted that they would not.

Vertical Amalgamations.

In periods when trade was in a quasi-stationary condition, Mr. Hichens continued, one had to attack the problem in a different way, and one of the things that must be considered very carefully was rationalisation. He did not say there were not other ways as well as rationalisation, but that was an important one. He did not necessarily mean by rationalisation that one should amalgamate with the object of securing a monopoly, because it seemed to him that a monopoly might not necessarily be more economical or more efficient. Another point was that the amalgamations must be of firms doing the same kind of business. In the last century, amalgamations took not so much this form—which was known as the horizontal form—as the vertical form. That was to say, that a steelworks, for example, amalgamated with a coal business in order to get its supply from there. Then they amalgamated with a shipyard or railway carriage works so that they could build up all their activities from the bottom to the top. That system of amalgamation was probably successful during times of expanding trade, because it meant that they could get the raw materials for the next succeeding stage at a reasonable price within their own borders, but it broke down during periods of bad trade, because during those periods the chances were that their own colliery or steelworks would not be able to supply the amalgamated concern as cheaply as they could purchase somewhere in the open market outside. The crowning blow was given to amalgamations of the vertical type by the Stinnes crash in Germany, and now they were quite out of favour—rightly out of favour, because conditions to-day were of depressed trade with competition at its fiercest.

Reduction of Costs.

At the present time, Mr. Hichens went on, we were driven back to improving our position by means of cheapening production, and it seemed to him that by means of rationalisation we should be able to bring down our costs very materially. Everybody was thinking to-day that one of the principal ways of bringing down costs was by the introduction of new and up-to-date machinery. In the old days, when it was found necessary to cut costs, the easy method of reducing wages would be adopted, but to-day people were wiser and recognised that it was essential to pay as high a wage as possible if the greatest efficiency was to be obtained. To-day people concentrated on improved mechanical devices in order to reduce costs, and he supposed the big manufacturing concerns of the country had been scouring the world with the object of trying to find the latest and best machine for some particular purpose. They did not always ask the question whether there was enough work to keep that machine occupied and to justify its expense. It seemed to him that rationalisation was something which was inevitable in this country. It was, perhaps, the most important thing that could be done for the basic industries.

Alloy Cast Iron.*

By D. Hanson, D.Sc., Professor of Metallurgy, Birmingham University.

During the past two years researches on alloy cast iron have been carried out in the author's laboratory, both on the theoretical and practical aspects of alloy cast iron; in the more practical of these researches we have been fortunate in securing the co-operation of a number of foundries in which large scale trials have been carried out based on laboratory investigations, and in this way it has been possible to obtain valuable data indicating some of the improvements that can be achieved in cast iron by the suitable use of alloys.

As in the case of the development of special steels, so in the evolution of alloy irons nickel as an alloying element has been the first to receive serious attention. The reasons for this are now quite evident: in the first place nickel is an element that can be readily added to cast iron without modifying the existing methods of manufacture; it is readily absorbed, provided certain quite simple precautions are taken; it is not liable to segregate, nor do losses of nickel occur during the addition, nor on remelting. Moreover, the large amount of attention now being given to nickel cast irons is justified by the promising results that have already been obtained both in the laboratory and the foundry, and, indeed, nickel is now regarded in most of the more advanced foundries as an essential item in their metal stock, and is being used regularly to achieve results that would be difficult or impossible to obtain without it.

The association of nickel with chromium has produced many notable advances in metallic alloys, both in steels and in non-ferrous alloys, and it is not perhaps surprising to find the same pair of metals in useful association in cast iron. Developments in this direction appear likely to be no less important than those of the simpler nickel cast irons.

Experience has already shown that the indiscriminate use of alloy metals in cast iron, without a proper appreciation of the character of the base iron and the action of the alloy, is likely to lead to disappointing results. This is in no way surprising; the development of alloy steels, especially in the early days of nickel steels, was accompanied by just such a period of difficulty before scientific alloying became general. The author can well remember numerous instances in which the injudicious use of alloy steel has led to disappointing results, failures and breakages, solely because the principles involved in the manufacture and use of such steels were imperfectly understood. Happily such instances are now rare, but we must inevitably pass through a similar stage before we can emerge successfully into the age of alloy cast irons. It would, perhaps, be more correct to state that we are now in the transitional period, for, thanks to our better scientific knowledge of metals and alloys, and to the many researches on this subject already carried out, not only in this country, but also abroad, especially in America, Germany and France, we have made very definite progress towards an understanding of the principles involved in making alloy cast iron.

Nickel in Cast Iron.

Before passing on to a consideration of the practical results of alloying, it will be as well to examine the fundamental actions involved, and since nickel enters into practically all the alloys that we shall consider here, and its action has already been fully investigated, it will be appropriate to devote some time to examining the effect of this element on the constituents of cast iron, and the accompanying changes in properties.

Cast iron can be considered as a complex alloy of iron and carbon in which the carbon can exist in two forms, iron carbide and graphite, the exact balance between these two depending partly on the composition of the iron and partly on the thermal history (this was amplified in a recent article in THE FOUNDRY TRADE JOURNAL (vol. 39, p. 223) by A. B. Everest); in certain special cases it may consist wholly of one form or the other. Now, of all the elements normally found in cast iron, the one that exerts the predominating effect in determining the character of the material is silicon, and as a first approximation we may regard cast iron as an alloy of iron, carbon and silicon. The other elements—phosphorus, manganese and sulphur—cannot be ignored in practice, and consideration of their importance in alloy irons will be given later on. We can, however, produce in iron-carbon-silicon alloys the principal characteristics of the cast irons. Starting with this simplification, Dr. A. B. Everest and the author have carried out investigations of the action of nickel on this system, and a consideration of these results will give a good general picture of the nature of the action of this metal on cast iron. That this is the case is amply confirmed by numerous experiments by the author and others on commercial irons.

A series of alloys was made by adding silicon and nickel to an iron-carbon alloy containing approximately 3.5 per cent. C, and the now well-known step-bar castings were made in each alloy; each step of these castings was examined by determining (a) its hardness and (b) its microstructure, and the results may be conveniently represented in diagrammatic form. Some typical hardness results are given in Figs. 1 and 2, representing respectively the effect of nickel on alloys containing no silicon and 1.2 per cent. silicon. For simplicity only two curves have been drawn on each diagram, corresponding to the ½-in. and 1-in. sections of the castings; diagrams representing intermediate sections have an intermediate form.

The curves in Fig. 1 are perhaps the most interesting; the ½-in. section, which is, of course, quite white in the original iron, is hardened considerably by additions of nickel up to 2 per cent., due, as microscopic examination reveals, to the direct hardening of the cementite-pearlite constituents, which remain substantially unaltered in nature. When, however, the nickel content exceeds 2 per cent. a softening occurs, due to the graphitising action of nickel in the iron carbide, which, for lower percentages had not been detected on this section owing to the rapid chilling; as still more nickel is added this softening is followed by a hardening, due to the transformation of the pearlitic matrix, first into sorbite and then into martensite. During this period the softening effect due to carbide decomposition and the hardening due to martensite formation may occur simultaneously, due to the rapid chilling action which retains carbide while inducing martensite formation. The rise in hardness is then followed by a fall, caused by the appearance of austenite, until, with high nickel additions (say 16-20 per cent. for this iron), the material consists entirely of graphite and austenite.

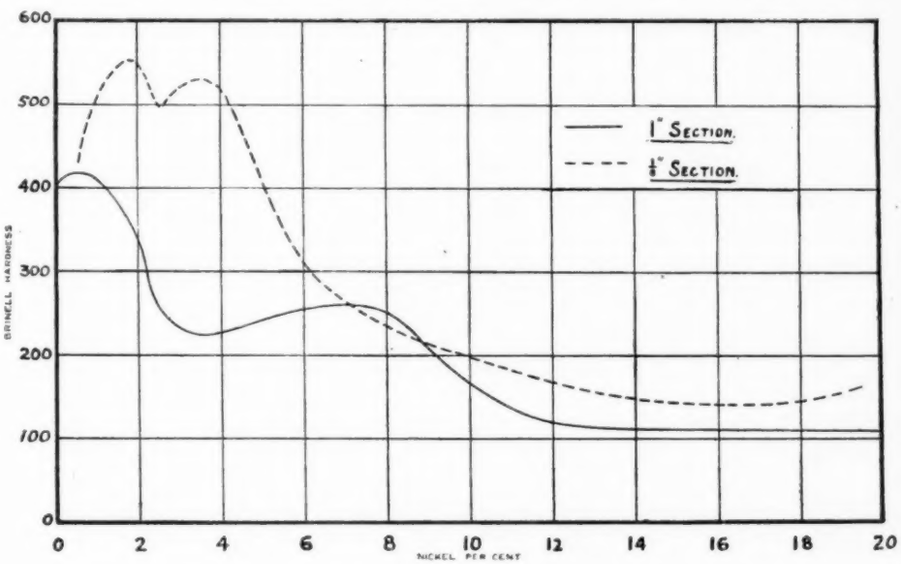


FIG. 1.—BRINELL HARDNESS OF ALLOYS AS CAST. SERIES 0. INITIAL SILICON, NIL.

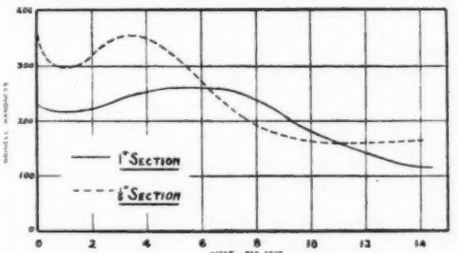


FIG. 2.—BRINELL HARDNESS OF ALLOYS AS CAST. INITIAL SILICON, 1.2 PER CENT.

The diagram for the 1-in. section is similar in type; it contains two peaks, but they are less intense, and extend over a wider range of composition. This is due solely to the difference in chilling effect resulting from the different section of the metal. The slower rate of cooling favours graphite formation, thus reducing the amount of nickel required to commence graphitisation, and lowering the intensity of its hardening action on white iron, *i.e.*, it depresses the first peak and causes it to occur at lower nickel concentrations; at the same time, the intensity of the matrix hardening is reduced, so that more nickel is required to produce martensitic structures, and, since graphitisation is facilitated, this martensite is formed in a matrix lower in carbon; *i.e.*, the second peak is depressed and occurs at higher nickel contents.

Thus we can recognise four main effects due to nickel:—(*a*) It hardens white iron (when the iron is of such a character that the cementite is stable); (*b*) it decomposes iron carbide, giving graphite; (*c*) it hardens the matrix, converting pearlite into sorbite or martensite; and (*d*) with high nickel, a soft austenitic grey iron is formed.

Fig. 2 shows similar diagrams for an iron containing 1.2 per cent. silicon. Here we observe that the first "peak" is absent, and that the first effect of nickel is to reduce the hardness. This is amply accounted for by the micro-structures, which show that the silicon prevented the formation of

* A Paper read before the Birmingham Section of the Institute of British Foundrymen.

the austenitic-cementite eutectic except in the thinnest sections, and the graphitising effect of the nickel additions became immediately effective. Practically all the commercial grey iron are of this type, though many of the commercial white irons fall within the type of Fig. 1.

Thus we see that the general effect of nickel can be represented by a characteristic curve, the effect of chill being to compress the changes into a smaller range of nickel additions.

Fig. 3 shows diagrammatically the structures of 1-in. sections of step-bar castings containing varying silicon and nickel, and amplifies the information given in Figs. 1 and 2.

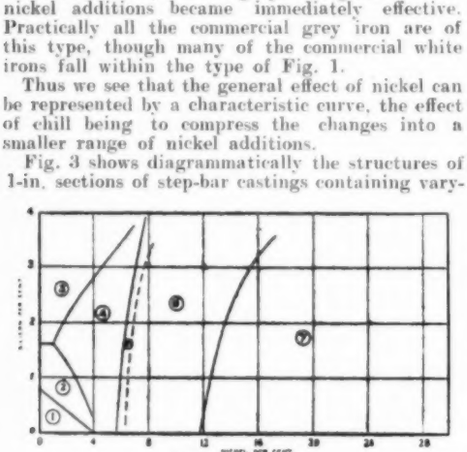


Fig. 3.—Constitution of Nickel-Silicon-Iron Alloys with 3.5 per cent. Carbon. As Cast. 1-in. Section.

Comparison of Effects of Nickel and Silicon.

Nickel, like silicon, promotes the formation of graphite; it is, in fact, quite possible to produce a grey iron with nickel, in the complete absence of silicon. But a consideration of the action of silicon at once reveals important differences in their behaviour. The first effect of silicon on a pure iron-carbon alloy is to harden the austenite cementite constituents, as Turner has shown, but this effect only occurs in irons outside the normal grey iron range. This is succeeded by a softening action, due to graphite formation, which is continued so long as any carbide remains in the iron; silicon not only causes the decomposition of eutectic and pro-eutectoid cementite, but removes the eutectoid carbide (pearlite) as well, so that a high silicon grey iron, in moderate or heavy sections (and, indeed, sometimes in thin sections) may consist entirely of ferrite and graphite. Silicon is not only a carbide softener, but a matrix softener as well, whereas nickel softens the carbide formed above the eutectoid range, while its graphitising action below this point is very mild and its hardening effect through sorbite formation is considerable. It is therefore a matrix hardener.

Above the critical range nickel and silicon may be said to supplement one another, but below this range nickel restrains the action of silicon in decomposing pearlite, and maintains a structure free from ferrite, while its own matrix hardening through sorbite formation is definitely in the opposite direction to the effect of silicon.

The Scientific Use of Alloy Additions.

From the foregoing it can readily be seen that the effect of a nickel addition will depend on the nature of the base iron and conditions of casting.

For example, an iron that is liable to chill will be softened in the chilled parts by adding a little nickel; an iron containing a wholly pearlitic matrix will, in general, be hardened, through pearlite refinement or sorbite formation; but an iron possessing an open grain and much free ferrite will in general be less affected, since the free carbides are already completely decomposed and the matrix possesses little pearlite upon which the nickel can act.

It may be, however, that in one and the same casting entirely different structures will exist: heavy sections may be grey while the thinner sections are chilled. Chilling can, of course, be prevented by raising the silicon content, but not without the risk of producing too open a grain, and too soft a matrix in the thicker parts. It is in such a case that the characteristic properties of nickel can be utilised with great advantage, since by a suitable addition the chilled portions may be softened by a break-up of the carbide, while the pearlite grey portions are refined and hardened. The nickel acts differently on the different parts, softening the hard portions and hardening the soft portions, thus producing a casting of more uniform hardness.

Nickel, therefore, must be used with due regard to the character of the iron, the nature of the casting and the effect that it is desired to produce—the indiscriminate use of this, or any other alloy addition, may well give unsatisfactory results, but used in the light of the general behaviour outlined above, it can effect improvements in the product otherwise unobtainable.

Effects of Nickel on the Properties of Cast Iron.

We may now consider the effects of nickel on industrial irons, and we shall devote our attentions mainly to high-grade grey irons, dealing first with irons low in phosphorus.

Chill and Hard Spots.

Nickel, in common with silicon, assists graphite formation, and is therefore effective in reducing chill and eliminating hard spots. This is well illustrated in Fig. 4, which represents fractures of fins of equal section cast in a high-grade automobile-cylinder iron; they contain 0.0, 1.12 and 1.84 per cent. of nickel respectively, and the elimination of chill and mottling is well illustrated. This is confirmed by many other instances in the writer's experience, and it is even possible to turn a white iron grey even when the silicon is very low, as is shown in Fig. 5, although higher nickel additions are here necessary.

According to Houston[1] two parts of nickel are equivalent to one part of silicon in eliminating chill. Experiments in the writer's laboratory are in agreement with this figure for some of the high-grade engineering irons, but in some cases rather more nickel may be required, especially in certain low-silicon mixtures of high-chilling tendency.

The reduction of chill and hard spots may be effected by silicon more cheaply than by nickel, but not without depreciation of the general physical properties of the casting through opening of the grain, and greater porosity and shrinkage, whereas, as will be shown later, nickel may be used to give simultaneously reduction of chill and increase in hardness and strength. But even where nickel is used solely with a view to the elimination of chill and without regard to the composition or properties of the grey portions of a casting, it is without appreciable deleterious effect on these portions.

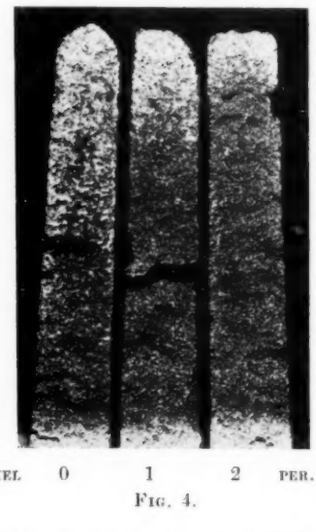
Table I, which refers to the castings illustrated in Fig. 4, shows the elimination of chill by nickel without appreciably altering the properties of the grey portions. This could not be effected by silicon. The tests refer to standard I.B.F. "M" bars cast 1.2 in. in diameter, tested on a span of 18 ins.

Table I.—*Mechanical Tests on 1.2 in. Diameter Bars.*
T.C., 3.30; Si, 2.08; Mn, 0.96; S, 0.10; P, 0.18.

Nickel—per cent.	—	1.12	1.84
Ratio G.C/T.C.	81.5	81.4	1.2
Transverse—			
Max. stress-cwt.	25.36	26.68	24.58
Modulus of rupture. Tons per sq. in.	33.65	35.38	32.60
Tensile—			
Max. stress. Tons per sq. in.	12.74	13.22	13.25
Chill: on ½-in. step ..	0.33	0.04	nil

Grain.

The effect of nickel on the grain (graphite structure) varies with the nickel added, and the nature of the iron. Small additions of nickel up to about 2 to 3 per cent. refine the grain of ordinary engineering irons, but above this amount the structure may become coarser. This effect has been repeatedly observed in Everest's and the author's experiments[2], and is substantially in agreement with the works of Wickenden and Vanick.[3] In irons that are already open in grain through too high silicon content, little refinement generally is effected.



Nickel 0 1 2 per. cent.

Fig. 4.

In order to obtain the maximum effect of nickel in this direction it is necessary to reduce the silicon content. It is well recognised that increasing silicon opens the grain of the iron. If therefore when nickel is added the silicon is reduced in the right proportion to maintain equal chilling properties, much greater grain refinement can be effected. This is, of course, the rational way to use nickel, and the author's experiments on cylinder irons, in which this adjustment was made, amply confirm the refining action of nickel used in this way.

Hardness.

The effect of nickel may be considered under two headings, (*a*) general effect, and (*b*) use of nickel to equalise hardness.

(*a*) It has already been shown that nickel may increase or decrease hardness according to the nature of the iron to which it is added. In regard to grey irons, there are two principal effects:—(1) Softening of the hard spots, such as chilled or mottled edges and free carbide (pro-eutectoid cementite), and (2) matrix-hardening through pearlite refinement and sorbite formation.

Fig. 5.

[1] D. M. Houston. Proc. American Society for Steel Treating, Jan., 1928. Vol. xiii, No. 1, p. 105.

[2] Everest, Turner & Hanson. J.I.S.I. 1922, Vol. cxvi, p. 125 Everest & Hanson, J.I.S.I. 1928, Vol. cxvii, p. 358.

[3] Wickenden & Vanick, American Foundrymen's Assoc. 1925 Vol. xxxiii, p. 347.

The first of these effects has been dealt with in discussing chill, and will be referred to again in dealing with wear and machineability. The second effect is amply illustrated by Brinell hardness results of which a number of examples are given in this Paper. It is usually readily detected even in irons in which the silicon content is not adjusted to the amount of nickel added, as in the first three series of Table II, but is most effective when the appropriate adjustment in silicon is made. Comparison of the above figures with those of the other castings given in the same table, in which the silicon was reduced to give irons of similar chilling tendency, at once reveals the great improvement effected, while the iron remains completely grey up to quite high Brinell numbers—in fact, machineable grey irons, having Brinell numbers exceeding 250 have regularly been obtained.

(*b*) *Equalising Hardness in Varying Sections.*—One of the most useful qualities of nickel is its equalising effect on the structure and properties of castings of variable section. As a rule, castings with thin sections, made in ordinary cast iron, must contain sufficient silicon to prevent the formation of chilled edges; but if they also contain heavy sections, the silicon will open the grain of the iron, with the accompanying reduction in strength, and liability to porosity and shrinkage. It is in such an instance that the dual action of nickel on the iron can be utilised with great advantage. The heavy sections can be refined by reducing the silicon by the appropriate amount, while chilling of the thinner parts, edges and corners, which would otherwise accompany this silicon reduction, is prevented by the addition of a suitable amount of nickel, which, while preventing the formation of unmachineable white iron in thin parts, will exert a sorbitising action generally on the matrix. Fig. 6 illustrates this

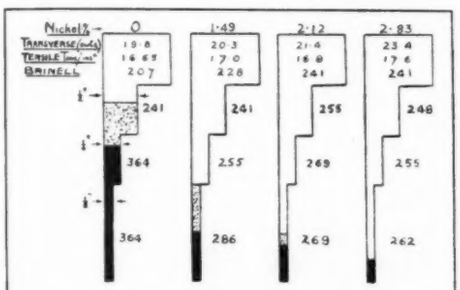


Fig. 6.—Step Bar Castings in Iron Containing T.C. 3.15; Si 1.15; Mn 0.4; S 0.05; and P 0.30 per cent.

effect in diagrammatic form; the diagrams represent the results of step-bar tests, the hardness of the different sections and the amount of chill being shown; on the heavy section is also included the results of standard transverse tests and tensile tests on 1.2-in. bars; the metal was melted in crucibles and cast into green-sand moulds, and contained 3.15 per cent. carbon; 1.15 per cent. silicon; 0.4 per cent. manganese; 0.30 per cent. phosphorus; and 0.05 per cent. sulphur.

The Effect of Nickel on Strength.

Castings of high strength, for which the demand is increasing, require a close-grained structure accompanied by a strong pearlitic or sorbitic matrix. The application of the principles of composition balance already described contributes to the solution of this problem. Irons possessing the highest strength must always contain sorbitising elements; nickel (and, as we shall see, chromium) has the required strengthening action, whereas silicon has not. The substitution of some silicon by the equivalent amount of nickel is therefore a logical solution of this problem, and here it is important to recognise that nickel addition to an iron of moderate or poor mechanical properties without simultaneous reduction of silicon cannot have a marked effect on strength since sorbitising without grain refinement may increase hardness and reduce chill, but will not greatly affect strength, since the refining action of nickel alone, on irons with normal or high silicon, though definite, is not sufficient to produce great improvement in strength. Silicon adjustment is here essential. Failure to appreciate this fundamental principle has been responsible for much unnecessary disappointment in the use of nickel.

The experiments tabulated in Table II, made on an automobile-cylinder iron, were carried out by Everest and the author with a view to obtaining harder and stronger irons of similar chilling tendency to the unalloyed iron. The improvements in strength obtained are very substantial, from 12.74 tons per sq. in. without alloy, to over 20 tons per sq. in., with only 1.12 per cent. of nickel (replacing 0.56 per cent. silicon—replacement ratio Ni/Si = 2/1). While the irons remained practically equal in regard to chill, the hardness of all sections was substantially improved,

Table II.—*Effect of Nickel on Strength and Hardness.*

Material: Automobile Cylinder Iron, T.C., 3.2–3.3%; Mn, 0.9%; Si, 0.10%; P, 0.18%.

Ni per cent.	Si per cent.	Transverse tests.[4] Load, cwt.	Transverse tests.[4] Mod. of rupture. Tons/sq. in.	Tensile strength.[5] Tons/sq. in.	Brinell numbers (step bar). 1 in.	½ in.	¼ in.	⅛ in.
.0	2.0	25.36	33.65	12.74	192	192	229	229
.7	2.0	25.52	33.87	13.09	197	199	229	235
1.12	2.0	26.68	35.38	13.22	199	210	229	235
.0[6]	1.3	—	—	—	228	250	364	340
0.93[6]	1.29	26.6	35.3	16.84	212	228	242	251
1.84[6]	1.35	28.0	37.4	16.70	225	241	251	286
1.22	1.42	29.46	39.0	18.5	226	232	273	292
1.12	1.44	28.43	37.6	20.5	228	230	250	386

[4] Transverse Tests on standard I.B.F. "M" Bars.
[5] Tensile Tests, pieces cast 1.2 in. diameter and tested 0.9 in.
[6] Carbon rose to 3.40 per cent. in these irons.

and completely grey sections having hardness values close to 300 were obtained, while some large omnibus-engine blocks were cast in this alloy iron to give cylinder bores with a Brinell hardness of 215 without machining difficulties through chill on the thinner sections.

Effect of Nickel on Machineability.

In discussing the question of machineability of cast iron we have to take into account the peculiar properties of the material. Cast iron can contain a great variety of constituents and structures varying from hard and white iron, containing much free carbide, to a dead soft material consisting essentially of ferrite and graphite. Most of the high quality engineering irons, with which we are most concerned, are required to possess a fair degree of strength and hardness, and these qualities are normally required in the heaviest parts of the casting. There is usually not much difficulty in securing such qualities, provided that the properties in the thinner sections are unimportant, but, unfortunately most castings are not simple in shape, and to secure the desired qualities in the heavier sections without chilling of the thinner portions, corners and edges, is frequently a matter of much difficulty. But even a small amount of chilled structure, which is practically unmachineable, is fatal in any position of a casting that must be machined. We may say, therefore, that for practical purposes, the machining qualities of an iron are mainly determined by its liability to chill. The property of nickel in preserving the general hardness while reducing chill is therefore of special value in improving machineability.

It is not only iron possessing a white structure that can give machining difficulty: the presence of carbide spots (pro-eutectoid cementite) in a grey iron is a common source of machining trouble, since the intensely hard constituent rapidly dulls the cutting edge of a tool and reduces its efficiency. In this connection also, the graphitising action of nickel can be utilised to break up the carbide colonies.

The characteristic action of nickel in breaking up carbide while preserving a strong matrix has therefore a special importance in connection with the production of hard and strong machineable castings and observations in the author's laboratory have repeatedly shown that commercially machineable castings can readily be made with Brinell hardness numbers exceeding 250.

There is another direction in which the equalising action of nickel may have an important bearing on machineability. We have shown that heavy sections, particularly in large castings, are liable to have a very open structure in ordinary irons, where silicon has to be maintained sufficiently high to prevent chill on the thin sections. This open grain, due to large graphite flakes, can give rise to machining troubles due to the tearing out of bits of machined surface by the tool, particularly when heavy cuts are taken; this produces a poor machined finish suggesting porosity in the metal. Here again, the proper use of alloy will close the grain of the iron and eliminate the trouble.

From the economic point of view the value of nickel in its relation to machineability is worth careful consideration, since the reduction of rejections in the machine shop alone may well justify the extra cost of the alloy addition.

(To be continued.)

Gift of Shares to Employees.

The well-known firm of Thos. W. Ward, Limited, Sheffield, celebrated its Jubilee on October 19, by a dinner at the Royal Victoria Hotel, Sheffield. The Company numbered about 300, consisting of directors, the Sheffield and other works staff, representatives from different parts of the country and overseas, together with 45 of the workmen who had been employed by the company for over 25 years.

Mr. Joseph Ward, J.P., chairman of the company, announced that in order to celebrate the Jubilee, he wished to mark in a tangible way the loyal services of the staff and workpeople, and he proposed to make a personal gift of a block of shares which would be distributed to about 250 members of the staff and workpeople who had been with the firm 20 years and upwards. These shares will be distributed in graduated amounts, according to the years of service.

Moulding Machine Causes Accident.

Joseph Barlow, of 5, Dale Street, Horwich, the noted Lancashire match bowler, received severe injuries to his face and scalp whilst working in the foundry at the L.M.S. Locomotive Works, Horwich, on Wednesday afternoon, October 24.

Mr. Barlow was altering the pattern in a moulding machine and in doing so thrust his head between the steel plates at the top and bottom of the machine. The hydraulic pressure supporting the top plate failed, and Barlow was trapped. An overhead travelling crane had to be requisitioned before he could be released. The unfortunate man was taken to the Accident Hospital attached to the works, and after receiving first-aid was removed in the Horwich ambulance to Bolton Infirmary, where his condition is reported to be "fair."

Runners.

By J. Ellis.

The question of runners is worthy of greater attention than it has hitherto been accorded. It is remarkable to see moulds finished beautifully in every particular, yet the runners receive but scant attention; they are scamped, dirty, and badly made. The cup or basin, down-channel, and gate are all slovenly made. In many cases pieces of sand are left loose in the down runner, channels are cut "any old how," and gates are misplaced, yet the moulder appears surprised if the casting is dirty, or waste.

It seems difficult to understand why this should be so, when everyone concerned knows—or ought to know—full well that the metal must first pass down and through the channel and in the gate before it can get into the mould; therefore, it is obvious that should any of these be dirty the resultant casting will be dirty also.

Many wasters—the cause of which is often attributed to dirty metal—are really caused by dirty runners, and it is not always easy to find the cause and determine exactly to what the defect can be attributed, because generally the runners are broken off the casting and thrown on the scrap heap or in the cupola before the defect is discovered. It would be well—when wasters are in evidence—if the runners were thoroughly examined; in many cases the cause of the trouble would very soon be located.

THIS paper was read before the Junior Section of the Birmingham Branch of the Institute of British Foundrymen. The Author, a founder and past president of the Institute, is now head of the research department of Messrs. William Cummings, Limited, of Glasgow, Chesterfield, and elsewhere.

There have been, and are being, made quantities of wasters through the runners being made too small, too large, not being connected properly, or being put in the wrong place, and dirty runners have caused innumerable wasters.

Unfortunately there is no rule determining the size, shape, or position of runners. This must always be left to the discretion and experience of the foundryman, except in the case of repetition work; then the exact size and shape and place of the runner can be determined by logical experiment and fixed on the pattern plate. One often hears the expression in the foundry, "Have big runners and dash the metal in as quickly as possible." This may be correct up to a certain point and for certain castings, but the great danger in this is that it would be fatal for some castings, as the dirt, and sullage, or silt may also get into the mould, which defects cannot be discovered until they are revealed by machining the casting and generally after a great deal of time and labour has been expended upon the resultant casting.

Mr. Ronceray advocates small runners as being the best to obtain good, sound, clean castings. This again is quite sound advice up to a point, but great discrimination must be exercised in this matter. For instance, soon after Ronceray propounded his theory of small runners a foreman—not an expert in runners had a casting to make, the weight of which would be about 7 cwt. and of a fairly thick section with no thin parts anywhere. He applied this small runner method to this casting, with the result that the metal set in the gate. As a matter of fact the size of the runner which he cut was just about large enough to run a casting of 7 lbs. weight. Then in the matter of small runners the condition of the metal obtainable must always play a large part in determining the size of the runner. In every case of small runners the metal must be very hot.

Fig. 1 shows a shutter runner or basin generally used in cases where it is necessary to pour some metal in at the bottom of a mould before pouring the greater part of the metal in at the top (see Fig. 20). With this type of basin the desired result can be achieved with one runner basin and one ladle, but sometimes two distinct basins and two separate ladles are employed for the same purpose. Both systems have their advocates.

When the well B is full, the plugs C are lifted, whilst meantime the shutters D are holding the metal in the well B until sufficient metal has been run down the runners C. Then the shutters are lifted, and the metal runs into the channel E and down the top runners F. This system allows hot metal to enter the top runners.

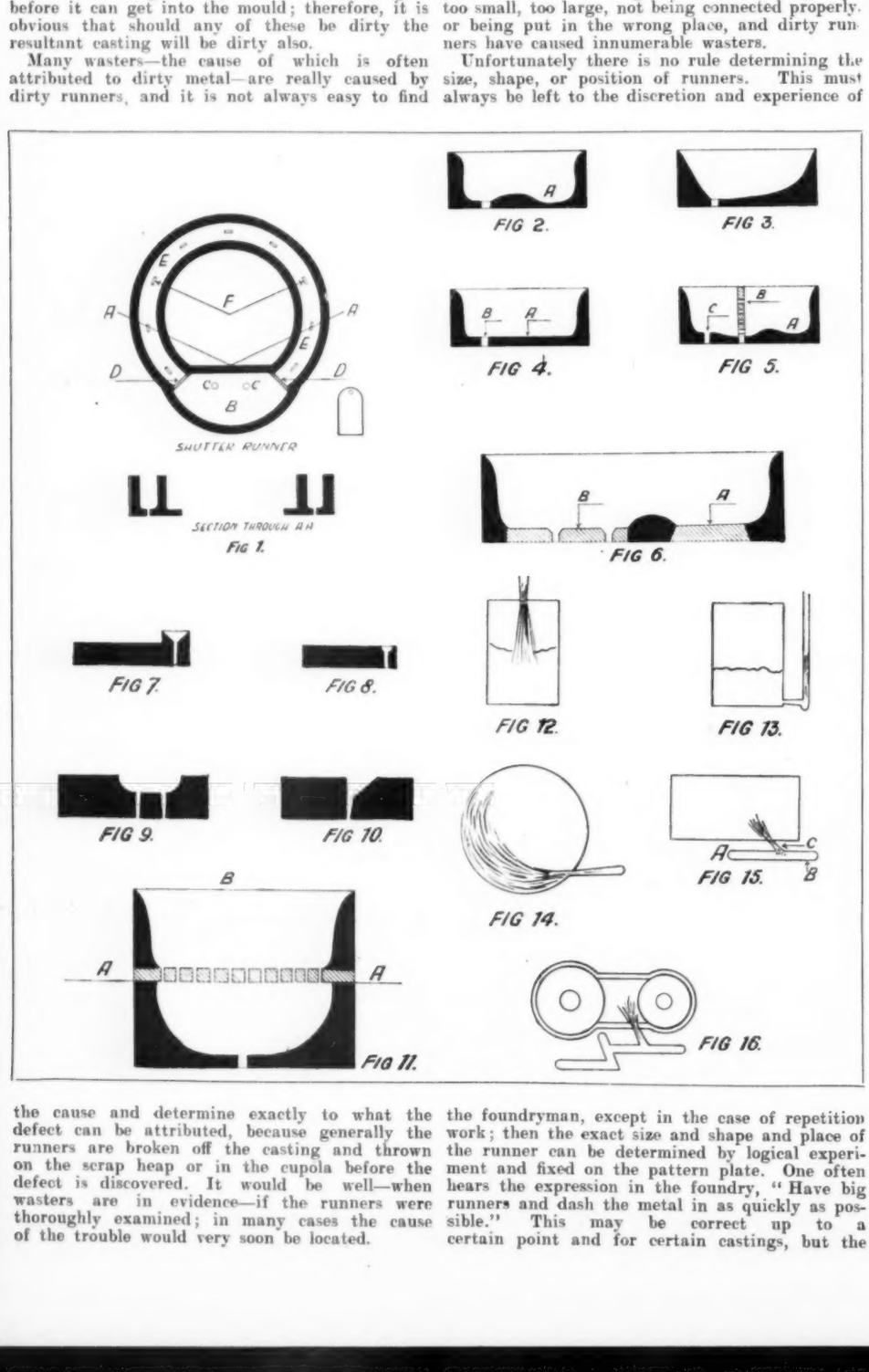
Another system is to plug all runners and only open the C runners when the desired quantity has entered there. This is not so good, as the metal round the plugs in the channel E is liable to cool off and perhaps set.

Fig. 2 *et seq.* show several kinds of basins, Fig. 2 being quite a nicely shaped one and safe to recommend for medium and large work. The well A is sometimes filled with metal from a small ladle before commencing to pour from the large crane ladle. This ensures a clean cast without splashing. This can be readily understood and appreciated by referring to Fig. 3, which is a very badly shaped runner, and the metal would very soon splash over, to the danger of all men near. Fig. 4 is quite a well-shaped runner basin, and is in great favour with the makers of motor castings. The entire bottom of this is of tin (A)—that is, a piece of sheet tin is placed on the moulding box before the runner cup is put on. A very clean cast is ensured this way, there being no sand on the bottom, none works up. The cup or basin generally becomes full before the tin melts at B to admit the metal into the mould. Some founders use only a small square of tin to cover the throat of the down runner, and some use specially made perforated skimming tins, which are equally as good and less expensive.

Fig. 5 is a system advocated by some; it is called the strainer-runner. When the metal enters the well A it receives a check by the loam- or sand-cake strainer B. The total area of the holes in B is greater than the area of the down runner C, therefore any scum or silt entering the well will float and be held by the strainer B.

Fig. 6 is generally used for large work. The bottom of the well A is made of loam, as is also the part surrounding the throats of the two down runners B. These loam cakes A prevent the tearing effect of the metal when it is poured in from the large crane ladle. Sometimes the drop from the lip of the ladle to the bottom of the well is 2 ft., or even more; then the cutting effect of the dash of metal on the sand is great, but with this method there is no danger of the bottom of the well washing away.

Fig. 7 is the ordinary method of runner cup for small work, and Fig. 8 is just a runner head made in the top part of the moulding box, and Fig. 9 is a basin with two down runners. This is



used in cases where two down runners are necessary but only one basin required.

Fig. 10 shows the wedge or knife runner, which is necessary on certain classes of work; whilst Fig. 11 is another method of the strainer-runner. In some foundries using a large number of these runners they are made on a special core-making machine and dried. The whole runner basin from the line A to the top B: this is a very effective method of keeping out all the dirt or kish, which always floats. The runners are made much more cheaply than the old method by hand.

Fig. 12 shows the system of top running, and Fig. 13 the bottom running. It is reasonable to conclude that metal so poured in as at Fig. 13 will have a tendency to cool off round the sides first. This being so, it is possible for any dirt to settle on the sides, as the metal entering the mould at the bottom seems to flow to the centre and push the top scum in curls towards the sides, but in the case of the top runner at Fig. 12 the reverse happens; the metal entering at the top in the centre has a tendency to encourage the scum towards the centre, and so bring it all up to the top of the casting, where generally provision is made for it to settle, and subsequently be cut off the castings as headers.

Runners for Chilled Rolls.

Fig. 14 shows a runner at a tangent. This is considered most important by chilled roll makers; in fact, one firm say they owe their great success to the rate of swirl of the metal in the mould. Too little or too much centrifugal action will endanger the casting, but the exact swirl will send the dirt or sullage to the centre of the metal during pouring, and bring it to the top out of the riser on the spindle.

Fig. 15 shows just an ordinary runner to obtain a clean machinable casting. The metal enters the channel at A and runs along to B, passing C, so that any dirt entering with the first drop of metal will not enter the gate C, on account of the nails there. This, of course, is a very effective strainer.

Fig. 16 shows the method of breaking the rapid flow of metal and arresting any dross or dirt. The gate is cut in the centre of the casting as the two ends are machined.

Fig. 17 is a four-spray runner to distribute the metal in the mould more evenly. It will be noticed that the sand in the channel between the gates A is cut back. This is to give the metal a clear run and not wash against any corner of sand. This is yet another method of trapping the dirt and securing a good sound casting, especially for machinery. Fig. 18 is just an ordinary four-spray runner for castings which have not to be machined sound, whilst Fig. 19 shows a similar runner, but with the down runners A misplaced. Referring again to Fig. 18, which has the down runner A in the correct place, it will be realised how stupid it would be to place the down runner as at Fig. 19.

Fig. 20 shows a fairly large casting, say 5 or 6 tons. This indicates the use of the shutter runner, shown in Fig. I. A given quantity of metal is let in at A, then the top runners, B, are opened, and the metal drops into the metal at the bottom. This is quite a good system, and generally ensures a good sound casting.

Fig. 21 shows the method of running a double-flanged drum. In such cases it is very important to keep the metal in the mould on the move. There is always the danger of the flow of metal being retarded momentarily when it reaches the point A A. As the metal is running into the well and boss B then sometimes there is a cold shut, and by placing another gate at this point, A, hot metal enters and livens the colder metal, and so prevents this cold shut occurring. The bottom gate B is always placed at a tangent, C, so that the metal can get a free run round the flange.

Figs. 22 and 23 show a tube 10 ft. long and 3 ft. dia. at the large end. Some founders like to place the gate at B so as to get a straight flow of metal in the mould, but the danger in this is the liability of the corners, C, washing away by the tearing effect of the metal entering there. A better way, proved by experience, is to place the gates at D; this allows the metal to drop to the bottom of the mould, and as soon as the mould has received metal up to the gates then there is a steady flow, through the metal being poured into metal. Another very good method of pouring this class of work is at E, with the flat runner—always providing the core is made properly the metal drops round the core, as at E, Fig. 23. There is far less danger of cold shuts when using this method.

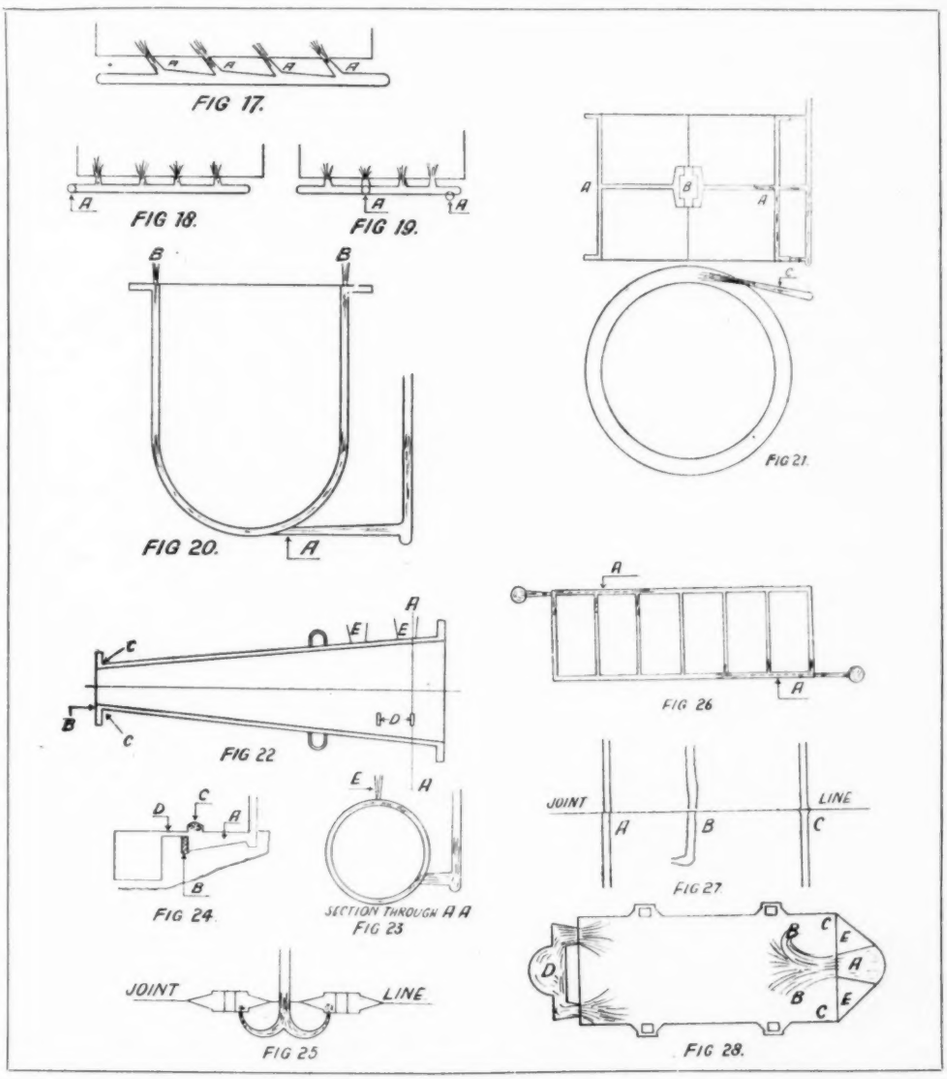
Baths and cisterns are always poured from the top, and in such cases the button is very important in preventing the runners breaking in. Fig. 24 is the trap runner, as the metal enters the channel A, and runs down to the sand or loam coke B; there it receives a check, when the channel is full. The dirt will rise to the ball in the top part of the box C, and there will remain so long as the channel is kept full and the clean metal will enter the gate D. This is quite a simple and very effective runner to ensure clean castings.

Fig. 25 is the horn runner and is not much in use to-day. It is chiefly used when castings are of such a shape that they can only be run on the boss and with four or more castings in a box. It is very difficult to run thin on top, but with the horn runner only one down runner is required to pour the four castings.

Fig. 26 shows an ordinary moulding box part, wherein the runners being placed at the ends up opposite corners, much can be learned by watching the flow of metal in such open sand castings. One thing is very noticeable, that is at A, quite near to the runner, the kish or silt will always assemble and invariably remain there.

Fig. 27, A, B and C, represent down runners, A showing a small lap at the joint. When this happens there is always the danger of some of the sand being washed away. B is a wretchedly made runner; one would not think it possible to see such runners to-day, yet it is a fact that they exist. How can anyone ever expect to get clean castings with such a runner made on any shape and unsifted floor sand rammed round it with no facing sand near? Black, or floor sand, will not stand the wash of metal through the runner. All runners should be made in facing sand. There is a greater wash of metal in the runners than there is in the mould. Yet this is the part of the mould which receives the least attention, and is often the cause of wasters. Therefore more care must be given to runners. C shows quite a good method; the edge of the down runner in the top part is slightly cut back and the mouth on the middle part is bell-shaped so that the metal drops clear.

Fig. 28 shows a mould for a large loam or foundation plate of about 10 tons in weight. The more common method of running or pouring is as shown at A. This is not the ideal way of pouring or running; as the metal enters the mould it naturally runs to the centre first; then as larger quantities enter the metal spreads out in a peculiar swirling motion, as is shown at B, and frequently men have to rake the metal into the corners C C. A better system is shown at D. Here the metal spreads out well over the mould; but a still better way is to have the runner the whole width of the mould, as indicated at E.



Aluminium v. Tinplate.—In Germany and America aluminium is said to be displacing tinplate used for food canning and cooking vessels.

Gases in Metals and Alloys.

At the opening meeting of the Lancashire Branch, Mr. E. Longden presiding, Dr. F. Johnson, D.Sc., of Birmingham, delivered an address entitled "Oxygen and Metals: Some Features of Their Relationship," which has already appeared in our columns. Opening the discussion the Chairman said it might be thought that Dr. Johnson's address was academic, but it had enlightened the members, so that the practical application of metals would be helped. They had learned something about the effects produced by various gases in the metals. There was still a tremendous field to be explored in that subject, but the investigations which had been made so far had produced important results, and it was a privilege to have the opportunity of hearing about them from one who had earned distinction in that field.

Mr. Makemson, in moving a vote of thanks to Dr. Johnson, said he believed that at this time of the year every teacher connected with a university, or college, was very busy attending to students who desired advice about the courses of study they should take, and with other administrative work. They were very grateful to Dr. Johnson for giving them this interesting lecture at such a time. The subject itself interested everybody who had anything to do with the melting of metals, but particularly the non-ferrous metals. The opening remarks, which he described in picturesque language, the struggle between oxygen and metals, must have had many sympathetic listeners among those who had to melt zinc when producing brasses and other non-ferrous alloys.

Waster Loss and Gas Content.

Mr. W. H. Meadowcroft said it was necessary for foundrymen to hear lectures of this sort in order to arrive at a solution of their difficulties, and he was impressed with the great amount of study which had been devoted to their service. It was a proof of great progress in the industry that men like Dr. Johnson were working systematically on these problems and were ready to disclose to foundrymen generally the information which they acquired.

The lecture brought to his mind previous experience of foundry practice in connection with the occlusion of gases, the causes of their occurrence, and the trouble involved in getting rid of them. One rather striking thing had come to his notice recently. The amount of bad work fluctuated. Sometimes imperfect castings came in groups. For a time things might go fairly straight, and then one struck a bad patch. Recently he had observed that better results were got when they did not cast direct from the furnace, but first cooled the metal off by heads. Perhaps Dr. Johnson could give an explanation why that happened.

Mr. Meadowcroft concluded by seconding the vote of thanks, which was carried unanimously.

Mr. J. Hogg asked whether Dr. Johnson considered that the gases which come from the materials of the mould itself have any effect? Or are the results described produced only by the gases which are in the actual metal?

Mr. T. W. Markland said he had wondered whether the magnetic oxide film, of which the lecturer had spoken, was simply on the surface of the casting, or penetrated into the iron. Certain castings were made which were used as washing boilers. The metal was blue, and they were rustless. Could Dr. Johnson say anything about those.

Ilmenite for Degasifying Molten Steel Baths.

Mr. W. West asked that, in view of the readiness with which aluminium was oxidised, whether the melting process would not be better carried out in an electric furnace than in any other type.

Further experiments had been carried out at Layland to de-oxidise a molten bath of steel by causing an exothermic reaction to take place between predetermined quantities of ilmenite ore and ferro-silicon on the top of the slag covering. The object being to cause titanium, which was the result of the reaction, to pass through into the bath of steel and so de-oxidise by extracting the oxides rather than increasing the power of solution of the metal for the oxides. The result of this method of de-oxidation is to make the steel very much like cream in its consistency which behaves very satisfactorily in the moulds.

Perhaps Dr. Johnson would enunciate some explanation why steel made in this way should possess superior qualities over the material made in the general way. For example, steel with 0.25 per cent. carbon de-oxidised with titanium reduction in the furnace gives an increased tensile strength, *i.e.*, 37 to 40 tons, with 25 per cent elongation, whereas the tensile strength of steel de-oxidised in the ordinary way with ferro-manganese and ferro-silicon would give only 30 to 32 tons tensile with 25 per cent. elongation.

He was open to receive any explanation, but could give the assurance that taking the same type of furnace for the production of the steel followed by the same annealing treatment, markedly superior results could be obtained, both in the physical results and the behaviour of the steel during solidification.

Composition from Film Appearance.

Mr. A. Jackson asked whether it was possible to learn anything of the composition of the iron in the ladle from observation of the nature of the oxidation film existing on the surface of the metal. In some castings after they had been taken out of the foundry and drilled, holes were found below the surface which were not apparent on the outside. In trying to account for those, and to prevent or remedy them, the foundrymen come up against a host of problems. Were they due to kish, to graphite, to air, to water, or to wrong mixing of the metal? Was it possible to say definitely what they were? And if it was possible to explain them, how could they be prevented?

There were variations in the colour. Sometimes it was dark, dirty grey; some kind of kish seemed to have been introduced. Again, one got a fairly solid casting, but at certain defective points there was a bluish portion. Sometimes the colour was almost sky blue. There were cases where the metal had evidently shrunk, but between the shrink hole and the surface were a number of holes, decreasing in size as they neared the top of the casting.

He might also refer to another interesting point which came to his knowledge recently. One assumed that if polished iron was embedded in concrete it would remain polished in after years until the concrete was broken. But in the particular instance he had in mind, soft iron had been used as a sheath for electric wires and encased in concrete in the belief that it would retain its property, but when the concrete was broken up some months later to find the cause of defective electric supply, it was found that electricity passing through had caused it to be corroded. Was it possible to explain those things?

Dry Sand Moulds Ameliorate Gas Troubles.

Mr. H. Sherburn said, Dr. Johnson, during his investigations into alloys, had observed certain phenomena, but was very careful to avoid the error which many foundrymen fall into of jumping to conclusions. It needed a very highly-trained man to thoroughly appreciate the facts of foundry practice, and many people who were running foundries at the present time had not had the training in physics and chemistry which would enable them to judge accurately why certain things happened—whether the cause of a blow-hole was an escape of gas, or some other influence.

Usually when molten metal was cooling, the effect was to force out dissolved gases of which silver is a striking example. But now Dr. Johnson came along and showed them that some alloys actually absorbed gases during cooling. If that applied to cast iron, it had an important bearing upon foundry practice.

He believed if all castings were made in dry sand moulds, many of the foundrymen's troubles would be solved more readily; but in most foundry operations involving the casting of large quantities of small articles, that was not at present a possibility. Permanent moulds had been advocated, but he was afraid they were coming along very slowly for general application. He thought, however, that if they had a permanent mould system in which the mould was perfectly dry, so that there was no question of moisture and the generation of gases like carbon monoxide, and so forth, they would be able to get a solution of many of the causes of unsoundness. But the problem was a very difficult one, and foundrymen should be warned against generalising upon inadequate evidence when, in nine cases out of ten, they had not sufficient data, nor the facilities for proving a case. The problems required to be studied in collaboration with men who had specialised in such work, and they were very grateful to Dr. Johnson for coming to speak upon them.

Application of Remelting.

The Chairman asked whether Dr. Johnson considered that there is any method by which founders can get rid of the gases from castings (say gunmetal) which have been oxidised and gassed during the melting down of the metal? It is quite a problem to know really what to do with such defective castings which must be again used for further castings of some kind. Is it possible to improve such metal by pre-solidification as so successfully employed with aluminium according to the process ascribed to Archbutt?

AUTHOR'S REPLY.

Professor Johnson said Mr. Meadowcroft had stated that better results were obtained by raising the temperature of the metal and then cooling it down before casting. Presumably what took place there, was what happened with most alloys, sufficient time was given for the gases dissolved in the metal to be evolved before the metal was poured. It depended upon several things, *e.g.*, the kind of metal dealt with, the kind of gases dissolved in the metal, the products of any reactions which took place between those gases and the oxygen in the atmosphere, or, conversely, between those gases and the oxides in the metal. It was quite conceivable that by keeping the metal exposed to the atmosphere for too long a time deterioration would be caused. He had himself pointed out, in the case of copper that, by allowing too long a time for the metal to solidify, they might get diminished soundness, because an opportunity was given for the dissolved gases to be released from solution and form bubbles entrapped by the solidifying metal.

Mr. Hogg referred to the material of which moulds were made. That was an important question. Most grey-iron moulds contained dissolved gas, and when the molten metal struck the surface there was a tendency for that gas to be absorbed by the metal of the casting. But this subject of mould materials was a very wide one, and it was not possible to venture upon it that afternoon in a satisfactory way. The general experience was that the nature of the dressing on the surface of the mould should vary with the metal which was to be poured into the mould. He would give an instance of that without venturing into the field of cast iron. That afternoon he had stressed the influence of oxygen; if he needed any justification to support his contention the simple experiment could be tried of taking a mould and dressing it with bone ash or other inert material, then pouring into it copper containing oxygen. They would be likely to get a smooth skin and a sound casting. If dressed with a carbonaceous dressing, the chances were that the smooth skin would not be obtained but there would be a honeycombed surface, owing to the reaction between the carbon dressing and the oxide which was in the metal.

Another question had reference to the magnetic oxide film formed on iron castings. So far as his remarks were concerned, they only related to that very thin film—the merest surface film—which was formed by the action of steam on the hot metal.

He did not know of any method of penetrating the whole of the casting by means of magnetic oxide. He had heard of "blue metal," and he believed castings which were rust-resisting were made from it. He was not sufficiently *au courant*

with this material to be able to give the explanation to his present audience.

No doubt Mr. West would find the electric furnace better than the air furnace for melting aluminium-copper alloys. Mr. West gave a very interesting account of making steel castings which had excellent properties by means of ilmanite and ferro-silicon thrown on the surface of the molten steel. That seemed a highly intelligent proceeding because titanium was readily oxidisable, and if it could be reduced in contact with the metal—being applied as a medicine—one had a very much better chance of getting high efficiency of action than if one used the metallic form which would be exposed to serious wastage by atmospheric oxidation. In the method described by Mr. West one had a mixture which yielded the metal *in situ*, and protected it long enough to enable it to penetrate the steel.

The nearest analogy to that, of which he was aware, was the old brass founders' use of balls made of a mixture of zinc oxide and charcoal. These balls were thrown on to the surface of the molten metal, and they trusted to luck. Sometimes luck helped them, and that was all. But there was reasoning in what they did.

How Titanium Acts.

He was not going to enter into any dogmatic explanation of the action of titanium except to say that it was a well-known scavenger; it had an affinity for carbon, for nitrogen, and for oxygen. If there is an ultimate state of affairs such that titanium, which will combine, with avidity, with nitrogen and carbon, and possibly form cyano nitride of titanium—it is not sure if that is the action which takes place—it would explain the efficiency of titanium as a scavenger and improver of the properties of cast steel.

He was afraid Mr. Jackson's question took him on to ground with which he was not very familiar. Was it possible to tell the composition of the iron in the ladle by observing the degree to which, or the rate at which, it oxidised? He could not say. Possibly some evidence of the action of oxygen on the metal could be derived. Between dull metal and metal which scintillated and threw out sparks, there was a great difference of composition; the intermediate mixtures and the differences with respect to impurities might give certain indications. He would not be surprised if one could gain some guidance regarding composition from the surface appearance of the metal in the ladle.

Another question put by Mr. Jackson was whether he could suggest how various defects could be obviated. To find out all about them and explain them was not quite the same thing as getting rid of them. He would not say it was, but if one was going to attack intelligently these foundry problems and difficulties, and try to solve them, surely the first step was to ascertain the real cause of them. Having ascertained that one would be in a far better position to attempt to improve practice.

To illustrate this point he would just refer again to one of the subjects mentioned in the Paper, namely, the formation of streaks on a polished sheet copper: if one found those streaks and no amount of polishing would remove them, they had a problem which could be solved more easily by knowing what the origin was. Having found out that the streaks were due to an oxide "cap" on the cast metal, certain methods suggested themselves of preventing the formation of the "cap." One could either cast vertically or use certain fluxes, or even, if necessary, some special atmosphere in which the formation of the "cap" could be prevented.

Then Mr. Jackson mentioned the colour of the film on the surface of cavities in cast iron. Here again it was difficult to say anything definite without investigating each case on its own merits. Those shrinkage cavities which had the surface covered with a dark-blue film had probably obtained that film by reason of the oxygen of the atmosphere gaining access to the cavity while the metal was solidifying. Whether the oxygen in the atmosphere itself was responsible, or the oxygen plus the water vapour from the mould, depended on mould condition.

He was not quite clear as to the question about iron tubes embedded in concrete. But when iron was in very close contact with a non-metallic substance, such substance being electro-negative to the iron, any stray electric current would promote corrosion more rapidly than if the iron were not in contact with such substance.

Mr. Sherburn had asked about the gas content of molten metal. His own experience led him to think that in most cases the gas content would increase with temperature. It was the converse of the case of dissolved gas in water. If water containing gas were heated the degree of solubility of gas was lowered, and ultimately when the water was boiled all the gases were driven out. But by increasing the temperature of molten metal the solvent power for gas was increased. Metal which had been overheated in the furnace was more apt to be contaminated with dissolved gases than metal which had been properly heated. Mr. Sherburn gave the instance of silver which in a molten form was capable of dissolving oxygen, but was incapable of holding it in solid solution. Solidification is apt to cause a loss of metal; the evolved gas is apt to spit particles of silver from the mass. That was what happened in the case of other metals with gases which were soluble in the molten state, but were insoluble when the metal solidified. At the point of solidification the metal was "spewed." Anyone present who had had the opportunity of seeing copper cast in moulds would probably be faimliar with the "spewing" which took place under certain conditions. The copper if overheated contained more gas than it could possibly hold in the solidified state. The gas released from solution coalesces to form large bubbles, and these exert a distinct pressure, sufficient in some cases to break the solidifying crust, and to eject some of the molten metal.

A question was put by the President: Could he suggest a means of getting rid of the gases from castings? He did not know that he could make any suggestion which would effect that, but a method of mitigating this trouble existed. He himself had always used the method during the last 20 years if he wanted to make a sample of very sound metal, particularly copper, by melting the required quantity in a crucible, under a protecting layer of flux, and then allowing it to solidify.

The idea was further developed by Mr. Archbutt, of the National Physical Laboratory; his method was to melt aluminium or whatever metal he was using, let it absorb gas in the normal way, then let it cool slowly to evolve those gases. After that all he did was to simply raise the temperature sufficiently to melt the metal to enable it to be poured.

In conclusion Professor Johnson thanked his audience for the way in which they had supported him.

Mechanical Engineers.

East Midlands Branch Formed.

Following numerous petitions, there has now been launched an East Midlands branch of the Institution of Mechanical Engineers, and the inaugural meeting, held at the University Buildings, Nottingham, was attended by Mr. R. W. Allen, President of the Institution, who occupied the chair. Among those present were Mr. W. H. Patshell (Past-President and chairman of the local branch committee), Sir Henry Fowler, Brigadier General Magnus Mowat (secretary of the Institution), and Mr. J. M. Dickson.

The meeting adopted the standard form of rules for branches, as approved by the Council. It was agreed that the area of the branch should comprise the counties of Derbyshire, Lincolnshire, Leicestershire, Rutland, Notts, and the Soke of Peterborough.

Mr. Schofield was appointed branch chairman and Mr. J. M. Dickson honorary secretary. A committee was also elected, and it was announced that two lectures had already been arranged, one at the Loughborough College on November 23 and the other at Lincoln on December 14.

Low-Grade Fuel Utilisation.

By Our Engineering Correspondent.

Significant it is that, although the world's demand for heat, light and power continues to increase rapidly, the coal production remains practically at a standstill. The latest German figures estimate the world's coal production for 1927 as 1,467,000,000 metric tons, which is only a small increase compared with 1926, and for about ten or twelve years past the average can be taken as 1,350,000,000 metric tons.

Two of the chief causes of this state of affairs are the remarkable growth of water power, with about 33,000,000 h.p. installed, and also the rapid increase in the production of petroleum, which has now reached 1,250,000,000 barrels per annum. But it is perhaps not generally realised that other factors also enter into the question, particularly, for example, the more scientific use of coal, that is increased thermal efficiency, and also the better utilisation of low-grade refuse material, not only as regards coal itself, but also many other solid fuels, including metallurgical coke breeze. In the latter connection typical are the results of a recent test carried out in Great Britain on the North-east Coast.

The normal practice in this particular works was to use a screened bituminous coal, costing 16s. 9d. per ton, giving an evaporation of 8.43 lbs. of water per lb. of coal, corresponding to 8.76 lbs. from and at 212 deg. F., which, incidentally, is much better than the average practice. The boiler plant, which is at a well-known iron and steel establishment, was then fitted with the "Turbine" forced draught steam-jet furnace, and there is now being burnt "Pond Duff" (washery settlings), costing 6s. 9d. per ton delivered, which seems a high price. However, the result is a great success, corresponding to no less than about 50 per cent. reduction in the nett cost of steam generation, while still more remarkable, the output of the plant has been increased by nearly 30 per cent., the evaporation being about 150,000 lbs. of water per hour as against a previous figure of 118,000 lbs., using ordinary good class screen coal.

The performance is approximately 6.70 lbs. of water per lb. of Pond Duff, equal to 7.06 lbs. from and at 212 deg. F., but the difference in the price, of course, means an enormous nett reduction, while it may be stated further that the hourly evaporation per individual "Lancashire" boiler with Pond Duff is 6,350 lbs., whereas with the screen coal the figure was 4,918 lbs.

Naturally, what can be accomplished in the field of utilisation of low-grade fuels depends very largely on the individual conditions, but here is a concrete case of a well-known firm cutting their coal bill in half, and the use of breeze from coke-oven plant is an obvious general application.

Patent Specifications.

The following list of Patent Specifications accepted has been taken from the "Illustrated Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The last numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

10,591. DEHN, F. B. (Griffin Wheel Company). Process of operating cupolas. 297,715.
11,347. TITANIUM ALLOY MANUFACTURING COMPANY. Obtaining zirconium compounds. 271,873.
16,718. CORSALLI, F. W. Processes for refining metals and alloys. 297,759.
24,353. TAYLOR, E. W. Tinning of flexible metal strips, tapes, or wires. 297,961.
32,135. CHARVIN, F. Machines for cold edge-rolling or flanging circular metal blanks. 297,307.
1,412. ROECKNER, M. Rolling metal tubes from hollow blocks. 285,894.
3,044. HULT, C. J. Die-casting machines. 298,023.
16,332. STEDEFELD, C. Welding of rails. 291,723.
9,143. ELLIS, G. B. (Granular Iron Company). Rail steels. 298,118.
11,275. PRYCE, L. Hollow drill steel. 275,560.
17,317. DOSSMANN, A. Treatment of tinned scrap iron. 298,103.
18,453. BEATTY, W. E. (Bell Telephone Laboratories, Inc.). Wire-drawing apparatus. 298,281.

Continental Foundry and Engineering Training.

Because of the interest at present being taken by the Institute of British Foundrymen in educational subjects, Mr. Delport's lecture on the above subject was particularly welcome, as it provided a fund of first-hand knowledge as to how these problems are being tackled in France and Belgium. The Paper, which was printed in a recent issue, gave rise to an animated discussion, of which the following is an extract.

EMPLOYERS' FEDERATIONS' HELP NEEDED.

The BRANCH-PRESIDENT, Mr. W. B. Lake, J.P., commended the Paper to the serious consideration of the foundry industry. It had shown very conclusively, he said, that much more trouble was being taken in France and Belgium than in this country to train men to become efficient foundry managers—and it was upon a supply of competent managers that the future of the foundry industry really depended. If we were to progress at the same rate as other countries we must have equally well-trained foundry managers, and in this country at present there were no such facilities as had been described by Mr. Delport for the thorough training of the men. It was important to note that it was the employers' organisation in France which had been instrumental in founding the Ecole Superieure de Fonderie. The foundry owners, having a strong organisation, were able to induce the French Government to contribute equally with themselves towards the cost of founding this "Foundrymen's University." We in this country had no such organisation to promote work of this kind, and until we did form an organisation of foundry proprietors we should never make any real progress. Mr. Delport's Paper had emphasised the necessity for forming such a body, and he personally felt very much indebted to Mr. Delport. Finally, the Branch-President moved a hearty vote of thanks to Mr. Delport, and emphasised that the Paper had been prepared at short notice, owing to the fact that Mr. J. B. Hoblyn, who was to have lectured that evening, was unavoidably prevented from doing so.

An Appreciation of Foreign Foremen.

MR. V. C. FAULKNER (Past-President of the Institute), who seconded the vote of thanks, said he had found that every British foundry manager who visited the Continent stressed the point that the British workman was wonderful and quite as good as any to be found on the Continent. He himself would grant that the British workman was quite as good as the continental workman, but was no better; he had worked in foundries in Scotland, in Middlesbrough, Sheffield, Manchester and Letchworth, as well as many in Creusot, France, in Italy, and in Spain, and had found the same spirit prevailing among the workmen in all those places, and wished to voice his personal indebtedness to the foundry foremen he had met abroad. Mr. Faulkner endorsed the Branch-President's statement that we could do nothing to move the authorities in the direction of helping to provide proper educational facilities until we had a strong employers' federation. There were in Great Britain at least half a dozen foundry employers' associations, but none of them of any great strength. He asked Mr. Delport whether the primary reason for the establishment of the Ecole Superieure de Fonderie was to give the foundry managers some status. Prior to the war the heads of all the shops in France, except the foundry, could adopt the title "Ingenieur," and it had occurred to him that the purpose of the school was not specially to give tuition, but to enable the head of the foundry to adopt the title in common with the managers of other shops. He regarded the school run by the Schneider firm at Le Creusot as one of the finest engineering schools in France, though he did not think it was very well known. He had been in personal contact with a number of the engineers trained there, and had found them more akin to the British managers than were any other engineers on the Continent, for they would never ask the workmen to do anything they were not capable of doing themselves. He must admit that some of the engineers from the Ecole Centrale des Arts et Manufactures and the Ecole des Mines were very much in the hands of the foremen, and some of them had made the mistake of refusing to co-operate with the foremen. They knew only the theory. Mr. Delport's Paper would be studied very closely by the Committee which had been appointed by the Institute of British Foundrymen to consider the question of the education of foundry apprentices. In Great Britain at the present time there existed wonderful opportunities for studying foundry work, but there was no co-ordination; the schools were far too scattered, and the certificates they issued were not of a national character.

National Certificates.

MR. WESLEY LAMBERT (President-Elect of the Institute and Past-President of the London Branch), dealing further with the Institute's activities with regard to the provision of educational facilities for the training of foundry students, said that there would be presented to the General Council at its next meeting a questionaire form dealing with this matter, and also with the question of awarding certificates, and that this form, if approved, would be sent subsequently to each of the Branches. He did not think that the examinations which it was hoped to arrange would be restricted to young students only, but that any Member of the Institute, if he felt so inclined, would be able to present himself for examination. Further, every endeavour would be made to ensure that the certificates awarded would have a national status. If the Institute itself could not supervise the examinations, then it would be necessary to arrange for supervision by an outside body of high standing; such as, for instance, the City and Guilds of London, or the Institution of Mechanical Engineers—which latter body at present was holding examinations for mechanical engineers. It had been found in the past that the certificates issued by local technical colleges carried very little weight outside the districts for which those colleges catered, and holders of certificates were at a disadvantage when they left one district for another. Works managers, not knowing very much about the technical school which had issued the certificates, regarded them merely as schools, and did not consider the certificates of much value. If, however, a scheme were put into operation by the Institute, the certificates issued would be of a national character, and works managers would know that the recipients of such certificates had been properly trained. If such certificates were to be awarded, it would not be long before the question of more adequate facilities for the training of students would have to be considered. Many suggestions had been put forward in that connection, and, in view of the interest which was being aroused, he did not think it would be long before we should have in this country some institution which would specialise in the training of the foundry worker to a much greater extent than could the ordinary technical schools which had to give tuition in a wide range of technological subjects. He wanted the members to realise that the parent Institute was very much alive to the importance of this question, and recognised the necessity of doing something in the direction of providing intensive instruction for foundry workers in Great Britain.

An American Contribution.

MR. H. L. MACKINNON, a visitor from Cleveland, U.S.A., said he had been impressed, as the result of attending the various meetings of the American Foundrymen's Association for a number of years, as well as the international meeting of foundrymen, held in America two years ago, by the great difference in the training of the men attending in later years and the training of those who had attended in earlier years. In a few short years the old rule-of-thumb methods had gradually disappeared from the foundries of the United States, and one would find university-trained men at the head of most foundries to-day. That change had been brought about by force of circumstances. The operations had become so extensive, and the necessity for effecting economies in all directions had become so important, that even the best training a man could get was not sufficient always to enable him to handle those operations to the best advantage. As an example of the progress which had been made, he referred to one foundry, the proprietors of which had commenced to instal mechanical equipment six years ago. Continuous moulding and pouring operations were then provided for. The foundry was 240 ft. wide and 400 ft. long. There were 1,600 people, including those in the core and cleaning shops, and they were making 180 tons of automobile castings per day. That was considered to be a very great achievement at that time. In June, July and August of this year, however, the mechanical equipment had been replaced, and since then, without the addition of one square foot to the floor space, and with less operatives than previously, the average output was over 800 tons per day. On one day the output had reached 1,011 tons in 9½ hours. The man at the head of that organisation was Mr. Arnold Lenz, who was trained at the University of Munich, and had subsequently worked as a patternmaker in the United States. He was one of the most polished gentlemen one could wish to meet. The size of the plant was now being doubled. He (Mr. MacKinnon) was furnishing the engineering equipment, and had to provide 50,000 hours of erection labour in 60 days, but could not find a place to put a man. The Vice-President in charge of operations had said that he must have 100,000 cars in January, no matter whether there was a roof or a floor on the building—and he would get them. There was a laboratory there, fully equipped and staffed with highly-trained men. The timekeeper there, who was introduced by Mr. Lenz, was a Graduate of Heidelburg, and was being trained for one of the highest positions in the organisation. Again, in an organisation such as that of the American Radiator Company, of Buffalo, where they were making 600 tons of castings per day, there must be thoroughly trained and highly skilled men at the top and well down into the body of the organisation; otherwise, the losses would become tremendous. Mr. Lenz had succeeded in reducing the number of wasters produced in his foundry from 10 to 2 per cent., which was a great achievement, seeing that he was dealing with water-jacketed, cored work, and the cores must be correct to within 3 to 3½ thousandths of an inch. Every core was ground and micrometered before it was put together, and micrometered afterwards, to ensure accuracy.

Mr. Lenz, however, had achieved what had seemed to be impossible of achievement; he had kept the percentage of defective castings at less than 3 per cent. for six months at a time, and for three months last summer the percentage was less than 2. Such achievements were possible only when thoroughly trained men were in charge. He felt sure that in the great iron-working industries in Great Britain there was room for much engineering training. Was it necessary to create a special school for the training of foundry engineers in this country, or were there not engineering schools which were training mechanical, electrical, and civil engineers, and which could extend their curricula in order to train foundry engineers? At the Kay School of Applied Science at Cleveland there were about 175 men in each class; probably 35 per cent. of them were taking mechanical courses, others were taking courses in metallurgy, mining, civil engineering and constructional work, and others were studying the building and planning of cities, and so on. The Massachusetts Institute of Technology was probably the best-known institution in the United States as an all-round engineering school. It had its own shops and equipment, and the course of training there was much more expensive than that discussed by Mr. Delport in his Paper. The fees ranged from 400 to 500 and 600 dollars annually, and even more in the case of some special courses, depending to some extent on the number of students taking those courses.

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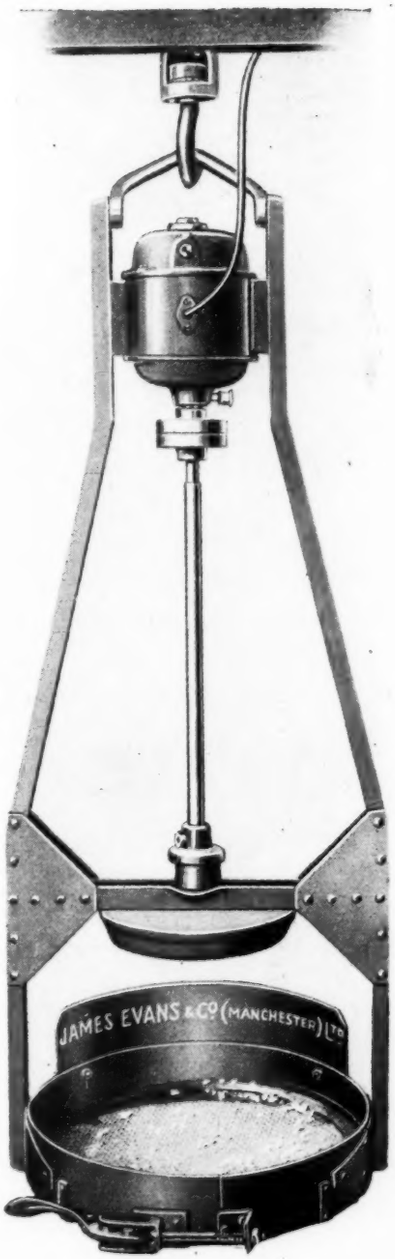

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Practical French Training.

Mr. A. S. Beech referred to the primary training of apprentices in the French foundries, which, he said, was the basis of the higher foundry training. It was necessary, as Mr. Delport had said, that a student must have had some training in a foundry before going to high foundry school, and he had found that candidates for entry into the high school—and, in fact, practically all the apprentices in France—were trained on a scale very different from that obtaining in this country. His experience was that the apprentice here was generally a sort of glorified labourer for the moulder, carrying sand, chaplets and so on. In France, on the other hand, the apprentice had actually to do the work; he had to work to a blue print, showing the sizes of the gates to be used, the construction of the moulds, supervise the pouring of the mould, and so on. Every morning there was an inquest on scrapped castings by someone in authority, when the cause of the defects were ascertained, for the future guidance of the apprentices. That was a matter which we in this country might consider with advantage. Mr. Beech endorsed the Branch President's remarks with regard to the necessity for establishing a strong employers' organisation in this country, because it was very necessary that the founders themselves should play a leading part in regard to schemes for the proper training of foundry workers.

AUTHOR'S REPLY.

Mr. Delport said that if he had been able to impart any new ideas to the foundry industry of this country, his time had been well spent. Replying to Mr. Faulkner's question as to the reasons for the establishment of the Ecole Superieure de Fonderie, he said the primary reason was to provide tuition, but undoubtedly the foundry engineer from that school had acquired a prestige which was not possessed by foundry engineers in the past. He agreed with Mr. Faulkner's remarks as to the attitude of the engineers coming from the high schools; they had not the attitude of the shop, and that was why the French schools years ago had had the reputation for turning out wonderful theorists who were not efficient in industry until they had acquired experience in the shops. With regard to Mr. Lambert's reference to national certificates, he said that the certificates granted to the students from the Ecole Superieure de Fonderie were endorsed by the Minister of Public Instruction, so that they were of a national character; the diplomas and certificates granted to engineers from the other schools mentioned were similarly endorsed. Dealing with the remarks of Mr. MacKinnon, he said that it seemed that it was economic conditions that had forced the foundry industry in America to realise the necessity for technical training for the foundry manager. On the other hand, it appeared, from what Mr. MacKinnon had said, that the engineer in the foundry in America was something more than a specialist in foundry work; the scope of the industry was so great, owing to the economic and geographical circumstances of the country, that a foundry manager must have a general training and not merely a specialised foundry education. Reference had been made to the Massachusetts Institute of Technology, and to the wide variety of subjects in which tuition was given. There was one school in France—the Ecole Centrale—whose curriculum embraced a very wide range of subjects, including architecture, industrial legislation, accounting, etc.; in fact, it might be said that there was much in it than was really necessary to the average engineer, but the training did serve to give the engineer a general outlook on industrial questions which might be valuable. Again, an engineer might at some time have to build a new shop, and he might know enough about architecture to enable him to appreciate what was being done in the building of that shop. Finally, replying to Mr. Beech, with regard to the training of apprentices in France, he agreed that the fact that the apprentices had to do work themselves from blue prints was a very important one. In many foundries the apprentices worked in groups under the supervision of the skilled moulders, and from the very first year they were given castings to make.

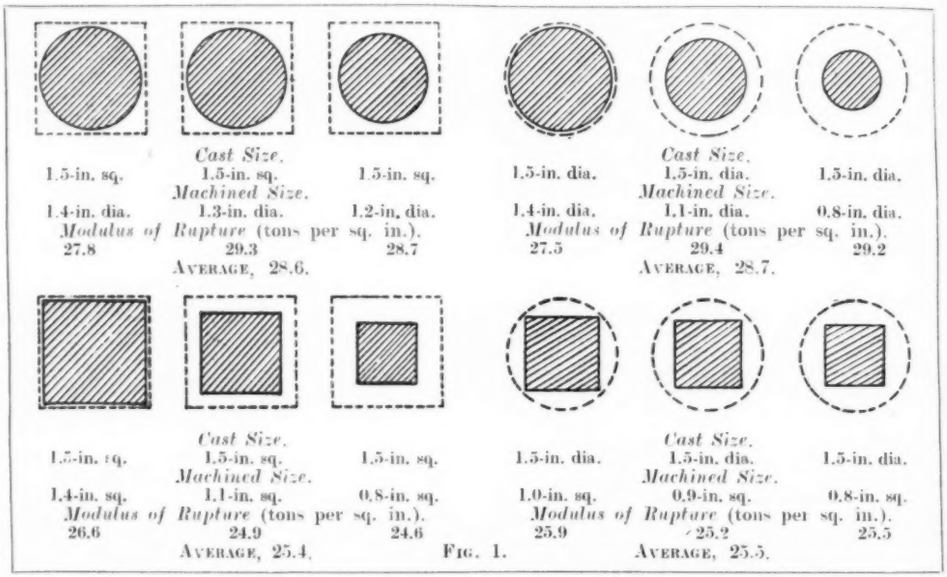
Transverse Tests on Round and Square Bars of Grey Cast Iron.*

By A. L. Norbury, D.Sc. (Senior Metallurgist, B.C.I.R.A.).

It is well known that square transverse test bars of cast iron give a lower modulus of rupture value than round bars of approximately the same cross-section. This difference has usually been attributed to a casting effect, such as chill or strain in the corners of square bars, consequent on more rapid cooling.

The following tests show, however, that a large part of the difference is due to the fact that the modulus of rupture formulæ generally used do not hold in the case of cast iron when applied to compare transverse test results on round bars with those on square bars.

The present tests consisted in casting† six square bars 1½ in. by 1½ in. by 16 in., and machining three of them to give round bars, large, medium, and small, and three to give square bars, large, medium, and small. Six 1½ in. diameter round bars, each 16 in. long, were also cast and three machined to give square bars, large, medium, and small, and three to give round bars, large, medium, and small. The sections as cast and as machined are shown in Fig. 1.


Cast Size.
1.5-in. sq. 1.5-in. sq. 1.5-in. sq.
Machined Size.
1.4-in. dia. 1.3-in. dia. 1.2-in. dia.
Modulus of Rupture (tons per sq. in.).
27.8 29.3 28.7
Average, 28.6.
Cast Size.
1.5-in. dia. 1.5-in. dia. 1.5-in. dia.
Machined Size.
1.4-in. dia. 1.1-in. dia. 0.8-in. dia.
Modulus of Rupture (tons per sq. in.).
27.5 29.4 29.2
Average, 28.7.
Cast Size.
1.5-in. sq. 1.5-in. sq. 1.5-in. sq.
Machined Size.
1.4-in. sq. 1.1-in. sq. 0.8-in. sq.
Modulus of Rupture (tons per sq. in.).
26.6 24.9 24.6
Average, 25.4.
Cast Size.
1.5-in. dia. 1.5-in. dia. 1.5-in. dia.
Machined Size.
1.0-in. sq. 0.9-in. sq. 0.8-in. sq.
Modulus of Rupture (tons per sq. in.).
25.9 25.2 25.5
Average, 25.5.
Fig. 1.

The twelve machined bars were then broken in transverse on 12-in. centres, and the results calculated as moduli of rupture according to the following formulæ.

Modulus of rupture in tons per sq. in.

$$\frac{W.l}{4} \times \frac{32}{\pi d^3} = \frac{W.l}{0.392d^3} \text{ for round bars.}$$

Modulus of rupture in tons per sq. in.

$$\frac{W.l}{4} \times \frac{6}{a^3} = \frac{W.l \,.\, 1.5}{a^3} \text{ for square bars.}$$

Where W = breaking load in tons.
l = length between supports.
d = diameter of bar.
a = length of side of bar.

The resulting moduli of rupture worked out at between 24.6 and 26.6 tons per sq. in. for the machined-square bars and between 27.5 and 29.4 tons per sq. in. for the machined-round bars. The results are given in Fig. 1. Amongst the machined-square test bars there was no systematic difference between the strengths of those machined from the cast-square bars and those machined from the cast-round bars. Similarly, amongst the machined-round test bars the strengths were the same irrespective of whether they had been machined from cast-square or cast-round bars. The average strength of the machined-square test bars works out at 25.5 tons per sq. in.; the average of the machined-round bars at 28.6 tons per sq. in., the maximum differences from the average figures being 1.1 tons per sq. in. (about 4 per cent.) in each case. In other words, the results on the machined-square bars are 11 per cent. lower than those on the machined-round bars. This difference is obviously not due to any casting effect in the present tests, and consequently must be due to the fact that the formulæ employed are not strictly applicable for comparing the transverse strengths of round bars with those of square bars in the case of cast iron. If the present results are examined in detail, it will be seen that the formulæ employed are applicable within the limits of experimental error (about 4 per cent.) as a means of comparing the transverse strengths of large (1½ in. by 1½ in.) square bars with small (0.8 in. by 0.8 in.) square bars, or of large (1.4 in. diameter) round bars with small (0.8 in. diameter) round bars, assuming that the cast bars do not vary appreciably in strength from edge to centre, which is apparently the case in the present tests.

Adamson and Bell* carried out transverse tests on a number of large and small round and square bars of cast iron, tested them as cast, and obtained lower modulus of rupture results on square bars than on round bars. They attributed these differences to the formulæ being inapplicable, but it is not clear that they do not attribute differences between small and large round bars and between small and large square bars to the same cause (inapplicability of formulæ) without sufficiently considering the differences due to the well-known effects of different rates of cooling on the strength of cast iron.

Tensile tests on two of the bars used in the present tests machined to 0.798-in. diameter gave ultimate strengths of 13.4 and 14.0 tons per sq. in.

* From Bulletin No. 21 of the British Cast Iron Research Association.

† The six square and six round bars were all cast vertically in green sand from the same runner and from the same ladle of cupola metal. The analysis was: T.C. 3.26; C.C. 0.76; Si 1.32; Mn 0.53; S 0.105 and P 0.98 per cent.

Cementation of Iron and Steel.—The cementation of iron and steel by carbon monoxide was studied by a Japanese investigator, Mr. C. Takahashi, by following the changes in pressure inside a steel tube during carburisation by carbon monoxide, and decarburisation by carbon dioxide, circulating outside the tube. The weight of carbon taken up by the iron was much greater than could result from the diffusion and subsequent decomposition of carbon monoxide, taking the accepted values for its solubility. The assumption that carbon deposited on the surface of the metal diffuses by means of carbon oxides present in the metal was untenable for the same reason. It was concluded that carburisation resulted from the diffusion of nascent carbon formed by the decomposition of the gas at the surface of the metal.

* "J.I.S.I.," 1924, No. 1, p. 347, and "Carnegie Scholarship Memoirs," Vol. 16, 1927, p. 1.

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Trade Talk.

TWO OF THE blast furnaces at the Shotts Iron Company's works, which ceased operations in September, are to resume shortly.

MESSRS. SWAN, HUNTER & WIGHAM RICHARDSON, LIMITED, Wallsend-on-Tyne, have booked a contract for a large whaling depôt vessel.

THE GENERAL MOTORS CORPORATION on December 1 will be operating a new foundry at Anderson, where they will be using exclusively "Holley" permanent mould machines. The Ford Company at Detroit is also extending its "Holley" plant.

MESSRS. BRAITHWAITE & COMPANY, (ENGINEERS), LIMITED, have received an order to supply all the steel transmission line towers required for the first part of the South-East of England Electricity Scheme. The towers represent more than 5,000 tons of structural steelwork.

THE CALEDON SHIPBUILDING & ENGINEERING COMPANY, LIMITED, Dundee, have received an order from Messrs. Alfred Holt & Company, Liverpool, for a twin-screw motor passenger and cargo vessel. Engines will be supplied by the North Eastern Marine Engineering Company, Limited, Wallsend.

AN ARRANGEMENT has now been entered into between Messrs. Alfred Herbert, Limited, and Wild-Barfield Electric Furnaces, Limited, whereby Messrs. Alfred Herbert, in addition to representing Wild-Barfield Electric Furnaces, Limited, in Scotland, India, Uruguay, Paraguay and the Argentine, will in future also introduce and sell these furnaces from all their British branches.

ACCORDING TO A cable from Johannesburg, there is good reason to believe that arrangements for amalgamation with or co-operation between the existing iron and steel concerns and the Government scheme have been completed. It is regarded as probable that the industry will be sectionalised and localised, Pretoria being the centre of steel production and Vereiniging of the finishing processes, as well as the centre for supplying Rand mining with its engineering requirements and for the manufacture of wire and pipes. Newcastle is to be the centre of the ferro-manganese industry.

THE NATIONAL UNION OF MANUFACTURERS, in a letter to the Home Secretary, state that they hope that the setting up by the Home Office of a committee to investigate the changes required in the organisation of the Factory Department to enable it to discharge adequately the additional duties foreshadowed by the Government Factory Bill of 1926 does not foreshadow any intention to re-introduce the Factories (No. 2) Bill in the form in which it was circulated last year or any similar Bill. The present, it is stated, is not a time when manufacturers in this country should be called upon to expend their sorely-depleted financial resources in meeting the cost of additional factory inspection, and an improvement in the present high standard of factory requirements should be deferred until industry has attained to greater prosperity.

WITH REFERENCY TO the agreement recently concluded between the tinplate manufacturers of South Wales and the United States, Mr. E. R. Crawford (President of the McKeesport Tinplate Company, the largest independent American producer), recently stated that there was no fear of over-production, and the spectacular growth of the American tinplate industry had not yet reached its peak. Although this year's production had surpassed by 10 per cent. that of any previous year, this growth was bound to continue. There were two main reasons for this: In the first place, tinplate was constantly finding new uses; in the second, no rival for it had yet been discovered in its staple use—the canning industry. All substitutes had failed. Experiments had, indeed, proved conclusively that tin was the best material for airtight food packages in existence.

TO HELP local industries in a scientific way, it was recently suggested by the North-East Section of the Institute of Chemistry that there should be established in Newcastle a Research Institute. Among other things, a memorandum from the chemists asserted that many collieries "were unable to state the composition of the coals in their different seams." The collieries resented this statement, and rejoined that the coals of every seam underwent careful analysis. An independent consultative body has gone into the idea of the proposed institute, and has made a cautious recommendation. It is, that in view of the fact that larger works have their own special research staffs and many small firms were not doing research, a committee of technical men be appointed with whom the small firms might confer. This, it is believed, would be a good beginning for the scheme, "and would obviate any appeal for funds which in the present state of industry would be difficult to obtain."

IN A STATEMENT issued by the Federation of British Industries, in reply to the recent charges made by the Post Office against the manufacturers of bronze wire, Mr. Thomas Bolton, chairman of the Non-Ferrous Metal Group, asserts that the price tendered by the British firms was actually only 8½ per cent. higher than the figure at which the Government gave these orders to foreign rivals in Germany and France, and not 35 to 40 per cent. higher as alleged. The foreign prices were from £92 10s. per ton against the British tendered price of £102, and this difference, it is stated, is more than accounted for by the lower labour costs of foreign manufacturers. There are only six firms producing bronze wire in this country, as there is practically no demand except from the G.P.O., and it has for years been the recognised practice for consultation as to price to take place between G.P.O. officials and these firms before formal tenders are sent in. The manufacturers feel, concludes Mr. Bolton, that, in view of the Prime Minister's appeal to employers, they have a right to expect Government departments to place orders, even at the slightly greater cost, which is due to higher labour charges and heavier taxation, with British firms.

BALDWINS, LIMITED, which recently underwent a scheme of reorganisation and writing down of assets, are making an issue of £1,000,000 6 per cent. first mortgage debenture stock at 96½ per cent., subscriptions for which were invited on Tuesday, October 23. The issue was oversubscribed, and the list was closed early on the same morning. The new stock is repayable on or before April 1, 1964. A cumulative sinking fund of 1 per cent. per annum, to be applied annually in purchases in the market at or under 102 per cent., including accrued interest, or by drawings at 102 per cent., will operate from April 1, 1933, the company having the option of redemption at 102 per cent. of all stock outstanding on or after October 1, 1938. As a result of the reorganisation, some of the more important subsidiaries will be merged into the main company, and certain unprofitable branches have been, or are being, closed down. In addition to repaying £500,000 4½ per cent. first debenture stock of Baldwins, Limited, the proceeds of the new issue, together with those of sinking fund policies for £282,972, will be used to repay £182,068 debenture stock of the Port Talbot Steel Company; to satisfy a preferential claim of £40,000 for taxes; to repay a special bankers' loan; and to provide for capital expenditure and working capital. It is shown that the net assets, including the proceeds of the present issue, cover the new debenture stock more than five times, while the net earnings for 1927-28 were £282,111, and after taking into account a loss of £75,026 on specified subsidiaries, the balance covers the service of the new issue nearly three times.

Personal.

MR. JOHN H. SANDIFORD has joined the switchgear sales department of the English Electric Company, Limited.

MR. B. H. BURTON, works manager of Messrs. Kerr, Stuart & Company, Limited, locomotive engineers, Stoke-on-Trent, has been elected President of the Stoke-on-Trent Association of Engineers for the forthcoming session.

MR. F. J. COWIE, senior partner in the Caledonian Engineering Company, Limited, and Mr. S. Y. Dixon, manager of the forge and rolling works of Messrs. Robert Heath & Low Moor, Limited, are among the candidates in the Bradford municipal elections.

MR. R. L. WEIGHTON, Professor of Engineering at Armstrong College, was presented with the diploma of Honorary Fellowship of the North-East Coast Institution of Engineers and Shipbuilders at the annual meeting of the Institution last week, in recognition of his long and distinguished connection with engineering, and his valuable contributions to the advancement of marine engineering science.

MR. A. J. CAMPBELL, of Messrs. William Beardmore & Company, Limited, Dalmuir, has been elected President of the Shipbuilding Employers' Federation. Messrs. J. H. Edwards, of the Middle Docks and Engineering Company, South Shields, and R. H. Green, of Messrs. R. H. Green and Silley Weir, London, have been elected vice-presidents. Mr. G. W. Barr, of Messrs. Vickers-Armstrongs, Barrow-in-Furness, has been appointed chairman of the Conference and Works Board of the Federation, with Mr. G. H. Stafford, of Messrs. Earles' Shipbuilding and Engineering Company, Hull, as vice-chairman.

Wills.

DYSON, F., of Leeds, ironfounder	£13,823
STRANG, J., late of Messrs. Joseph Strang (1921), Limited, iron and brass founders, Ramsbottom	£19,716
BLACKWOOD, D., of Villafield, Johnstone, managing director of J. Fyfe Donald & Company, Limited, ironfounders ...	£11,178

Obituary.

MR. ERNEST E. W. BERRINGTON, of Messrs. Berrington, Son & Watney, consulting engineers, died at Wolverhampton recently, aged 54.

MR. H. F. SPILSBURY, works manager of Messrs. Heenan & Froude, Limited, Worcester, engineers and founders died recently at the age of 54 years.

MR. ROBERT TRAILL, a director of Messrs. Swan, Hunter & Wigham Richardson, Ltd., shipbuilders and engineers, of Wallsend, died in Glasgow recently. Mr. Traill commenced his career in 1884 as an engineering apprentice at the works of the Wallsend Slipway & Engineering Company, Limited, of which firm he eventually, in 1915, became a director. In 1920 he resigned his position with the company in order to take up the appointment of manager of the engine works of the Fairfield Shipbuilding & Engineering Company, Limited, which position carried with it a seat on the board of the company. He returned to Wallsend and was elected a director of Messrs. Swan, Hunter & Wigham Richardson, Limited, early this year.

Reports and Dividends.

Babcock & Wilcox, Limited.—Interim dividend of 7 per cent., tax free, on the ordinary shares.

Stanton Ironworks Company, Limited.—Interim dividend on the ordinary shares of 4 per cent., actual, free of tax.

Coventry Chain Company, Limited. — Profit, £101,000; final dividend on the ordinary shares of 7 per cent., making 10 per cent., less tax, for the year, together with a bonus of 2½ per cent., less tax.

Samuel Osborn & Company, Limited.—Balance after providing for depreciation, £36,254; brought in, £9,423; preference dividend, £14,366; dividend of 5½ per cent., less tax, on the ordinary shares; to reserve fund, £5,000; carried forward, £13,418.

Fairfield Shipbuilding & Engineering Company, Limited.—Profit, after providing for depreciation, taxation, etc., £54,917; brought forward, £88,366; dividend of 5 per cent. on the ordinary shares, less tax; carried forward, £92,034.

Electrolytic Zinc Company (of Australasia), Limited.—Gross profit, after transferring £145,000 to depreciation reserve, £460,847; net profit, £363,025; brought forward, £188,663; to sinking fund reserve, £12,100; to developments, £50,000; dividends, £312,000; carried forward, £177,589.

Sinclair Iron Company, Limited.—Net profit, £27,640; to reserve account, £11,932; dividend of 1s. per share, less tax, £12,789; carried forward, £2,919. Sums of £2,386 and £4,374, in respect of income-tax and preliminary expenses respectively, have been transferred from the reserve account, reducing it to £5,171.

William Beardmore & Company, Limited.—Trading profit, £88,079; interest on debentures, notes, loans, etc., £229,885; net loss for year, £141,806; debit balance brought forward, £253,522; provision for special losses on stores and work in progress, £136,770; debit balance at December 31, 1927, £532,099.

Contracts Open.

Bradford, November 10.—Stores, for the Tramways Committee. Mr. R. H. Wilkinson, general manager, 7, Hall Ings, Bradford.

Brussels, November 6.—Diesel engines, for the Inspecteur-General, Chef du Service des Approvisionnements du Ministere des Colonies. The Department of Overseas Trade. (Reference A.X. 7021.)

Cardiff, November 6.—500 yds. of 2-in. wrought-iron water pipes, etc., for the Rural District Council. Mr. W. Farrow, engineer and surveyor, 20, Park Place, Cardiff.

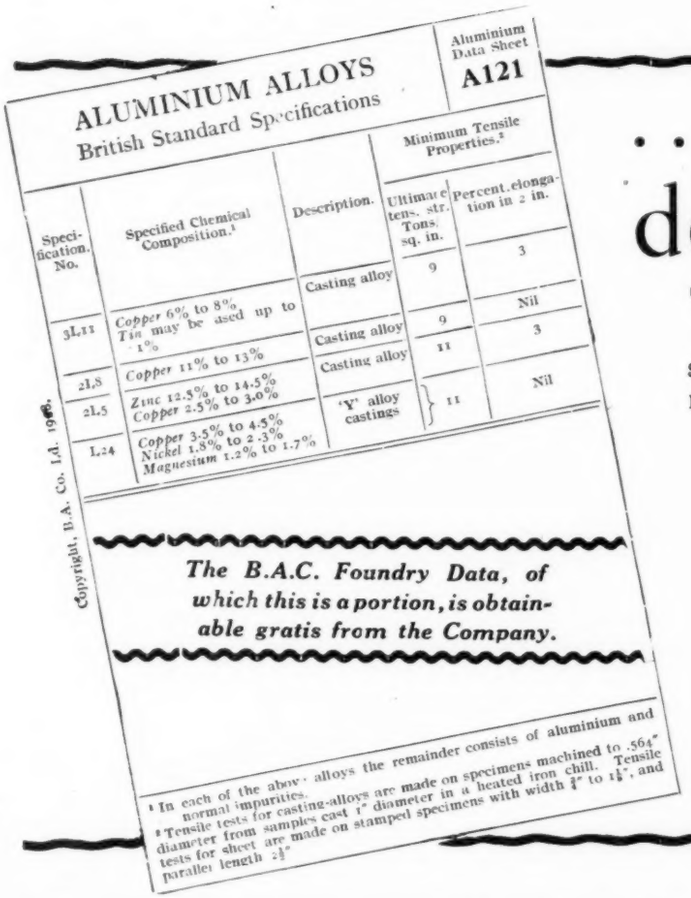
Dublin, November 26.—Supply and erection of six electrically-driven pumps, for the Borough Commissioners. The City Engineer, Castle Street, Dublin. (Fee £2 2s., returnable.)

Dublin, November 12.—Iron and steel stores, for the Dublin United Tramways Company, Limited. The Company's Offices, 59, Upper O'Connell Street, Dublin.

Halifax, November 19.—1,300 tons of cast-iron pipes and special castings, for the Town Council. Messrs. G. H. Hill & Sons (Manchester), civil engineers, 40, Kennedy Street, Manchester. (Fee £1 1s., returnable.)

Johannesburg, November 22.—Ten miles of copper trolley wire, for the Town Council of Johannesburg. The Department of Overseas Trade. (Reference A.X. 6990.)

Southend-on-Sea, November 13.—100 tons of cast-iron manhole shafts, etc., for the Town Council. Messrs. Dodd & Watson, County Chambers, Corporation Street, Birmingham. (Fee £2, returnable.)



ALUMINIUM ALLOYS
British Standard Specifications

Aluminium Data Sheet
A121

Specification No.	Specified Chemical Composition.[1]	Description.	Minimum Tensile Properties.[2] Ultimate tens. str. Tons/sq. in.	Percent. elongation in 2 in.
3L11	Copper 6% to 8% Tin may be used up to 1%	Casting alloy	9	3
2L8	Copper 11% to 13%	Casting alloy	9	Nil
2L5	Zinc 12.5% to 14.5% Copper 2.5% to 3.0%	Casting alloy	11	3
L24	Copper 3.5% to 4.5% Nickel 1.8% to 2.3% Magnesium 1.2% to 1.7%	'Y' alloy castings	11	Nil

The B.A.C. Foundry Data, of which this is a portion, is obtainable gratis from the Company.

[1] In each of the above alloys the remainder consists of aluminium and normal impurities.
[2] Tensile tests for casting-alloys are made on specimens machined to .564" diameter from samples cast 1" diameter in a heated iron chill. Tensile tests for sheet are made on stamped specimens with width ½" to 1½", and parallel length 2½".

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F.T.J. 3.11.28

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THE detriment of unsound constituents and the difficulty of correct proportioning in small mixes are overcome by using B.A.C. ready mixed aluminium alloys.

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TYPICAL ANALYSIS (if necessary guaranteed)

ASH	not exceeding	8%
SULPHUR	,, ,,	0·8%
VOLATILE	,, ,,	1 %
MOISTURE	under	1·50%

Iron and Steel Markets.

Pig-Iron.

MIDDLESBROUGH.—The outlook for the near future of the Cleveland pig-iron trade continues unsatisfactory, and, from a business point of view, has quite failed to meet the sanguine anticipations of more active conditions expressed in market circles only a few weeks ago. Home and export demands remain practically stationary at the same dead levels of a month ago, with few signs of a revival of buying on anything like a normal autumn scale. In the meantime it must be evident that stocks at consumers' works have been diminished to almost, if not quite, vanishing point, while buying is still restricted to minimum lots, just sufficient for week-to-week requirements. It is, however, still difficult to convince the consumer that by delaying purchases cheaper prices will not be obtained, and until this conviction is realised to the full extent any improvement in bulk buying is out of the question. In the conditions thus outlined it will suffice to add that quotations are unchanged, as follow:—No. 1 Cleveland foundry iron, 68s. 6d. per ton; No. 3 G.M.B., 66s.; No. 4 foundry, 65s.; No. 4 forge iron, 64s. 6d., f.o.t. or f.o.b.

The continued increase of output of British steel is reflected in the revival of activity in the hematite markets, in which home demands are in better volume than has been experienced for a long time past. Consequently prices are distinctly firmer, with East Coast mixed numbers quoted at 70s. and No. 1 quality at 70s. 6d. to 71s. per ton at furnaces. On the North-West Coast Bessemer mixed numbers are 69s. to 70s. per ton at works.

LANCASHIRE.—Following a period of fairly substantial buying recently, the local markets for foundry pig have returned to quieter conditions, though prices are well maintained, as follow:—Derbyshire No. 3, 68s. to 68s. 6d. per ton, with Staffordshire 6d. to 1s. less; Cleveland, 79s.; and Scottish, 87s. 6d. to 90s. per ton, all delivered to works in the Lancashire area.

THE MIDLANDS.—Inquiries for foundry pig-iron in this area have of late been on a slightly more satisfactory scale, but buying is still limited in scope at about the following figures:—Northamptonshire, 57s. to 58s.; Derbyshire No. 3, 60s. to 61s.; North Staffordshire, 60s. to 61s.; with Scottish brands, 90s. to 91s. delivered locally.

SCOTLAND.—The condition of the Scotch pig-iron market is unaltered and the demand is exceedingly limited. Founders continue to buy only their immediate requirements, as there is nothing in the state of the market to warrant them buying ahead.

Finished Iron.

With the exception of makers of best quality bars, business in most departments producing finished material continues slow, while the Staffordshire works are experiencing much competition from Derbyshire and Lancashire makers. Prices for crown iron are anything from £9 per ton, the Staffordshire works quoting in the region of £9 10s. for this grade. Nut and bolt iron is quoted at between £8 15s. and £9, but few orders are developing on account of the Belgian competition.

Metals.

Copper.—With an advance of some £10 on the corresponding figures for this period in 1927, the position in the market for warrant copper is steadily increasing in strength, both in regard to cash and forward transactions. This continued firmness may be attributed partly to the excellent American statistics for last month.

Closing quotations are :—

Cash.—Thursday, £66 12s. 6d. to £66 15s.; Friday, £66 18s. 9d. to £67 1s. 3d.; Monday, £67 15s. to £67 17s. 6d.; Tuesday, £68 2s. 6d. to £68 3s. 9d.; Wednesday, £67 7s. 6d. to £67 8s. 6d.

Three Months.—Thursday, £67 3s. 9d. to £67 5s.; Friday, £67 10s. to £67 11s. 3d.; Monday, £68 8s. 3d. to £68 7s. 6d.; Tuesday, £68 13s. 9d. to £68 15s.; Wednesday, £67 17s. 6d. to £67 18s. 9d.

Tin.—Due mainly to speculative activities, the tin market has been very erratic. Differing opinions on the subject are held on all sides; some would have it that, although propaganda has died down a lot, tin will cost as much as £250 before long. From another source comes the confident assertion that the price will fall below the £200 mark within the next few months, and, again, a suggestion from the Far East is that the level will sink even as low as £170.

Official closing prices :—

Cash.—Thursday, £220 15s. to £220 17s. 6d.; Friday, £221 to £221 5s.; Monday, £223 2s. 6d. to £223 5s.; Tuesday, £226 7s. 6d. to £226 10s.; Wednesday, £227 5s. to £227 10s.

Three Months.—Thursday, £219 12s. 6d. to £219 15s.; Friday, £220 to £220 5s.; Monday, £220 15s. to £220 17s. 6d.; Tuesday, £222 15s. to £223; Wednesday, £221 15s. to £222.

Spelter.—Slightly more interest has been taken of late in the market for ordinary spelter, in which the chief feature has been the unwillingness of producers to part with the metal at current prices, thus giving considerable backing to the argument that values are almost level with the cost of production.

Daily quotations are :—

Ordinary.—Thursday, £23 18s. 9d.; Friday, £23 18s. 9d.; Monday, £24 1s. 3d.; Tuesday, £24 2s. 6d.; Wednesday, £24 1s. 3d.

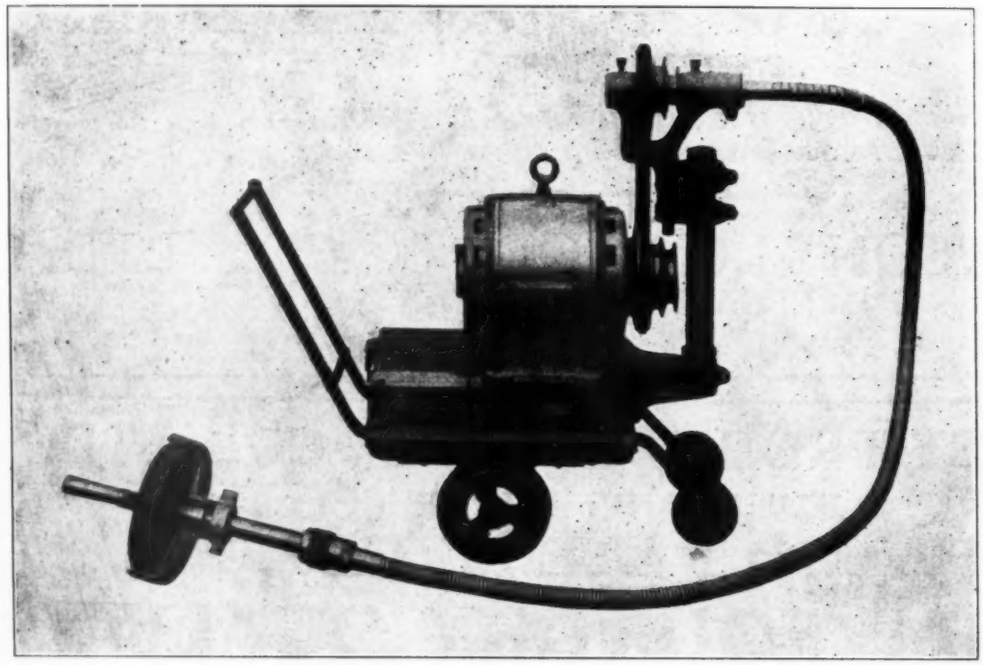
Lead.—In connection with the position of soft foreign pig, the settlement of the Australian shipping trouble should clear the outlook considerably. Prices are steady, demand has been remarkably strong, and the situation generally is satisfactory.

Closing prices :—

Soft Foreign Prompt.—Thursday, £22 5s.; Friday, £22 5s.; Monday, £22 5s.; Tuesday, £22 3s. 9d.; Wednesday, £22.

Scrap.

Generally described, the markets for foundry scrap metals may be reported to be fairly steady, and in the Midlands this week there has been a good demand for heavy cast iron and for heavy machinery cast-iron qualities, broken into cupola sizes, 65s. delivered being quoted. Light cast-iron scrap is rather scarce, and 55s. delivered is realised without difficulty. In Scotland the cast-iron scrap market is unchanged, and sellers find it rather difficult to get outlets. Machinery cast-iron scrap, suitable for foundries, is unchanged at 65s. to 66s.



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Complete Portable MOTOR-DRIVEN EQUIPMENT
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1½ H.P. motor and starter, mounted on a rubber tyred trolley with teak base—steel column mounted on special cast iron base with bracket and clamp for belt adjustment and 3-speed pulleys.

Coupled to 8 ft. Flexible Shaft with 11/16" inner core, aluminium guard and 8" × 1" emery wheel with outer ball bearing detachable handle.
All wired ready for use with 12' of 3-core cab tyre cable and 3-pin plug and socket.

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¶ LIGHTNESS AND EASE OF HANDLING;
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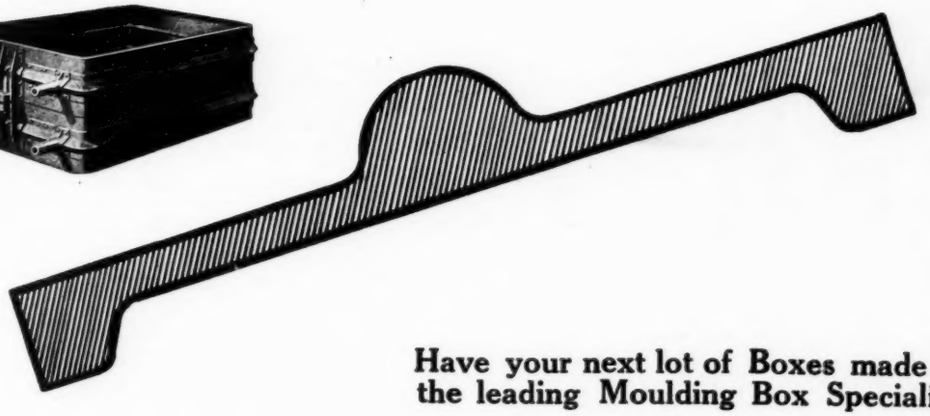
¶ PERMANENT ACCURACY.

These are the paramount essentials of the modern moulding box.

Sterling Boxes embody all these qualities. They are made from solid ribbed rolled steel of the special section shown below.

Some of the largest and most up-to-date foundries in the country are now completely equipped with Sterling Boxes.

All Sterling Boxes are made to suit the individual requirements of each Foundry. We will drill them to match up to your existing pattern plates or odd-sides and fit them with bars to suit your special patterns.



Have your next lot of Boxes made by the leading Moulding Box Specialists.

STERLING FOUNDRY SPECIALTIES LTD.

London Office:
13, VICTORIA STREET, S.W.1.

BEDFORD

Telephone: 3345 BEDFORD.
Telegrams: "STERFLASK, BEDFORD."
Code: WESTERN UNION.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	67	7	6
Three months	67	17	6
Electrolytic	74	15	0
Tough	71	15	0
Best selected	72	0	0
Sheets	98	0	0
India	80	0	0
Wire bars	72	7	6
Do. November	72	2	6
Do. December	72	2	6
Ingot bars	72	2	6
H.C. Wire rods	79	5	0
Off. av. cash, September	63	11	3
Do. 3 mths., September	64	1	8¼
Do., Sttlmnt., September	63	11	3
Do., Electro, September	70	1	0
Do., B.S., September	66	19	4½
Aver. spot price, copper, Sep.	63	11	3
Do., Wire bars, September	70	6	0
Solid drawn tubes			13¾d.
Brazed tubes			13¾d.
Wire			10½d.

BRASS.

Solid drawn tubes	12d.
Brazed tubes	14d.
Rods, drawn	11½d.
Rods, extd. or rlld.	7¼d.
Sheets to 10 w.g.	10½d.
Wire	10½d.
Rolled metal	9¾d.
Yellow metal rods	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£	s.	d.
Standard cash	227	5	0
Three months	221	15	6
English	226	10	0
Bars	227	0	0
Straits	227	12	6
Australian	227	10	0
Eastern	226	0	0
Banca	228	15	0
Off. av. cash, September	215	15	7½
Do., 3 mths., September	212	17	3
Do., Sttlmt., September	215	15	3
Aver. spot, September	215	15	7½

SPELTER.

	£	s.	d.
Ordinary	24	1	3
Remelted	22	12	6
Hard	19	5	0
Electro 99.9	27	10	0
English	24	10	0
India	20	10	0
Zinc dust (Nom.)	35	5	0
Zinc ashes	7	15	0
Off. aver., September	24	11	2½
Aver., spot, September	24	9	11¼

LEAD.

	£	s.	d.
Soft foreign ppt.	22	0	0
English	23	10	0
Off. average, September	21	18	2¾
Average spot, September	22	1	0

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	33	0	0
Do. V.M. ex whf.	31	5	0
Rods	39	0	0
Boiler plates	29	0	0
Battery plates	30	10	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	57	10	0
Chinese	39	12	6
Crude	33	10	0

QUICKSILVER.

	£	s.	d.
Quicksilver	23	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

	£	s.	d.
Ferro-silicon—			
25%	7	17	6
45 50%	12	0	0
75%	19	0	0
Ferro-vanadium—			
35/50%	14/- lb. Va.		
Ferro-molybdenum—			
70/75% c. free	4/3 lb. Mo.		
Ferro-titanium—			
23/25% carbonless	1/1 lb.		
Ferro-phosphorus, 20/25%	£18	0	0
Ferro-tungsten—			
80/85%, c. fr.	1/3 lb.		
Tungsten metal powder—			
98/99%	1/7½ to 1/8 lb.		
Ferro-chrome—			
2/4% car.	£30	0	0
4/6% car.	£21	2	6
6/8% car.	£20	0	0
8/10% car.	£20	0	0
Ferro-chrome—			
Max. 2% car.	£32	10	0
Max. 1% car.	£37	0	0
Max. 0.70% car.	£42	0	0
70%, carbonless	1/- lb.		
Nickel—99%, cubes or pellets	£175	0	0
Ferro-cobalt	9/- lb.		
Aluminium 98 99%	£98	0	0
Metallic chromium—			
96 98%	2/7 lb.		
Ferro-manganese (net)—			
76/80% loss	£13	15	0
76/80% packed	£14	15	0
76/80% export	£14	10	0
Metallic manganese—			
94/96%, carbonless	1/6 lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	£0	2	3
Finished bars, 18% tungsten	£0	2	9

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to ⅛ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ¾ in.	3d. lb.
Do., under ¼ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

Scrap from high-speed tool steel—	
Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Hvy. steel	3	7	6 to	3	8	6
Bundled steel and shrngs.	3	2	6 to	3	7	0
Mixed iron and steel	3	0	0 to	3	2	6
Heavy cast iron	2	17	0 to	2	18	0
Good machinery for foundries				3	2	6
Cleveland—						
Heavy steel				2	15	0
Steel turnings				2	8	0
Cast iron borings				2	2	6
Heavy forge				3	7	6
Bushelled scrap				2	18	6
Cast-iron scrap				3	2	6
Lancashire—						
Cast-iron scrap	2	15	0 to	3	5	0
Hvy. wrought	3	2	6 to	3	5	0
Steel turnings	2	5	0 to	2	6	0

London—Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	54	0	0
Brass	39	0	0
Lead (less usual draft)	19	15	0
Tea lead	16	15	0
Zinc	15	10	0
New aluminium cuttings	64	0	0
Braziery copper	50	0	0
Gunmetal	50	0	0
Hollow pewter	150	0	0
Shaped black pewter	105	0	0

PIG-IRON.

(f.o.t. unless otherwise stated.)

N.E. Coast—	
Foundry No. 1	68/6
Foundry No. 3	66/-
Foundry No. 4	65/-
Forge No. 4	64/6
Hematite No. 1	70/6
Hematite M/Nos.	70/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	78/-
,, d/d Birm.	86/-
Midlands—	
Staffs. common*	67/6
,, No. 4 forge	56/-
,, No. 3 fdry.	60/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	54/0
,, fdry. No. 3	56/6
Derbyshire forge	59/-
,, fdry. No. 3	60/6
,, basic	65/-
Scotland—	
Foundry No. 1	75/-
,, No. 3	70/-
Hem. M/Nos.	74/-
Sheffield (d/d district)—	
Derby forge	61/-
,, fdry. No. 3	65/-
Lincs. forge	63/-
,, fdry. No. 3	65/-
E.C. hematite	81/-
W.C. hematite	84/-
Lincs. (at furnaces)—	
Forge No. 4	58/6
Foundry No. 3	60/6
Basic	59/6
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	68 6
Northants foundry No. 3	—
Dalzell, No. 3(special)	100/- to 102/6
Summerlee, No. 3	87/6 to 90/-
Glengarnock, No. 3	87/6 to 90/-
Gartsherrie, No. 3	87/6 to 90/-
Monkland, No. 3	87/6 to 90/-
Shotts, No. 3	87/6 to 90/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.) nom.				10	5	0
Nut and bolt iron	8	15	0 to	9	0	0
Hoops				11	10	0
Marked bars (Staffs.) f.o.t.				12	0	0
Gas strip				11	10	0
Bolts and nuts, ¾ in. × 4 in.				15	5	0
Steel—						
Ship plates	8	7	6 to	8	12	6
Boiler plts.				10	10	0
Chequer plts.				10	12	6
Angles				7	17	6
Tees				8	17	6
Joists				7	17	6
Rounds and squares, 3 in. to 5½ in.				8	17	6
Rounds under 3 in. to ¼ in. (Untested)				7	15	0
				and upwards		
Flats, over 5 in. wide and up				8	7	6
Flats, 5 in. to 1½ in.				7	17	6
Rails, heavy				8	10	0
Fishplates				12	10	0
Hoops (Staffs.)				10	10	0
Black sheets, 24g.	10	0	0 to	10	10	0
Galv.cor.shts.,24g.	13	10	0 to	13	15	0
Galv. fencing wire 8g. plain				12	10	0
Billets, soft	6	5	0 to	6	10	0
Billets, hard	7	2	6 to	7	12	6
Sheet bars				6	0	0
Tin bars				6	0	0

PHOSPHOR BRONZE.

	Per lb. basis
Strip	1 2½
Sheet to 10 w.g.	1 3
Wire	1 4
Rods	1 3
Tubes	1 7½
Castings	1 2

Delivery 3 cwt. free.
10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON AND STEEL.

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	20.70
No. 2 foundry, Valley	17.00
No. 2 foundry, Birm.	16.26
Basic	18.70
Bessemer	19.26
Malleable	19.26
Grey forge	18.20
Ferro-mang. 80% d/d	105.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	33.00
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.90
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.90
Skelp, sheared steel	1.90
Steel hoops	2.20
Sheets, black, No. 24	2.85
Sheets, galv., No. 24	3.50
Sheets, blue an'l'd, 9 and 10	2.00
Wire nails	2.55
Plain wire	2.40
Barbed wire, galv.	3.20
Tinplates, 100 lb. box	$5.25

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham and North.	
,, foundry	16/-
,, furnace	14/3
Midlands, foundry	—
,, ,, furnace	13/6 to 14/6

TINPLATES.

f.o.b. Bristol Channel ports

I.C. Cokes	20×14 box	18/- to	18/3
,,	28×20 ,,	,,	36/3
,,	20×10 ,,	,,	27/3
,,	18¾×14 ,,	,,	19/3
C.W.	20×14 ,,	,,	15/6
,,	28×20 ,,	,,	33/6
,,	20×10 ,,	,,	22/-
,,	18¾×14 ,,	,,	15/9
Terneplates	28×20		33/6 per box basis f.o.b.

SWEDISH IRON.

Bars, hammered, £17 10 0 to	£18 10 0
Rolled Ord.	£15 15 0 to £15 17 6
Nail rods	£15 7 6 to £15 15 0
Keg. steel nom.	£32 to £33
Faggot steel nom.	£22 to £25
Blooms, according to quality	£8 to £12
Pig-iron	£5 15 0 to £6 0 0

all f.o.b. Gothenburg

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	Fittings.
Gas	67½%	50%
Water	63½%	45%
Steam	60%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (cash).

		£	s.	d.		
Oct. 25		66	12	6	inc.	6/3
,, 26		66	18	9	,,	6/3
,, 29		67	15	0	,,	16/3
,, 30		68	2	6	,,	7/6
,, 31		67	7	6	dec.	15/-

Electrolytic Copper.

		£	s.	d.		
Oct. 25		72	15	0	inc.	10/-
,, 26		73	15	0	,,	20/-
,, 29		73	15	0	No change	
,, 30		74	15	0	inc.	20/-
,, 31		74	15	0	No change	

Standard Tin (cash).

		£	s.	d.		
Oct. 25		220	15	0	inc.	5/-
,, 26		221	0	0	,,	5/-
,, 29		223	2	6	,,	42/6
,, 30		226	7	6	,,	65/-
,, 31		227	5	0	inc.	17/6

Tin (English ingots).

		£	s.	d.		
Oct. 25		220	0	0	No change	
,, 26		220	10	0	inc.	10/-
,, 29		222	0	0	,,	30/-
,, 30		225	0	0	,,	60/-
,, 31		226	10	0	,,	30/-

Zinc Sheets (English).

		£	s.	d.		
Oct. 25		33	0	0	No change	
,, 26		33	0	0	,,	,,
,, 29		33	0	0	,,	,,
,, 30		33	0	0	,,	,,
,, 31		33	0	0	,,	,,

Spelter (ordinary).

		£	s.	d.		
Oct. 25		23	18	9	dec.	1/3
,, 26		23	18	9	No change	
,, 29		24	1	3	inc.	2/6
,, 30		24	2	6	,,	1/3
,, 31		24	1	3	dec.	1/3

Lead (English).

		£	s.	d.		
Oct. 25		23	10	0	No change	
,, 26		23	10	0	,,	,,
,, 29		23	10	0	,,	,,
,, 30		23	10	0	,,	,,
,, 31		23	10	0	,,	,,

AVERAGE PRICES OF STEEL RAILS.

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	£ s. d	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1908 ..	6 2 6	6 0 0	6 0 0	5 15 6	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 15 0	5 10 0	5 16 3
1909 ..	5 5 0	5 5 0	5 5 0	5 0 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 0	5 5 9
1910 ..	5 5 0	5 7 6	5 7 6	5 7 6	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 10 0	5 8 11½
1911 ..	5 15 0	5 15 0	5 15 0	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 12 6	5 13 1½
1912 ..	5 13 1	5 15 0	5 15 0	5 15 7	6 1 6	6 6 3	6 7 6	6 8 0	6 11 3	6 12 6	6 12 6	6 13 9	6 4 4
1913 ..	6 15 0	6 14 4½	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	6 12 0
1914 ..	6 10 0	6 10 0	6 6 3	6 0 0	6 0 0	6 0 0	5 14 0	6 2 6	6 13 9	6 12 0	6 7 6	6 7 6	6 5 3½
1915 ..	6 10 6	6 17 6	7 5 0	7 12 6	7 12 6	7 17 6	8 17 6	9 2 6	9 2 6	9 2 6	9 7 6	10 10 6	8 6 6½
1916 ..	10 19 4	11 0 0	11 0 0	10 18 9	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 9 10
1917 ..	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6
1918 ..	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6	10 17 6
1919 ..	10 17 6	13 7 6	13 7 6	13 7 6	15 0 0	15 10 0	16 0 0	16 10 0	16 10 0	16 10 0	16 10 0	17 5 0	14 12 11
1920 ..	18 15 0	19 5 0	20 7 6	22 0 0	23 0 0	23 0 0	24 0 0	25 0 0	25 0 0	25 0 0	25 0 0	25 0 0	22 18 11½
1921 ..	23 5 0	20 4 0	18 0 0	17 0 0	15 0 0	15 0 0	14 0 0	14 0 0	14 0 0	11 12 6	10 10 0	10 0 0	15 4 3
1922 ..	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 10 0	9 0 0	8 15 0	8 15 0	8 15 0	8 15 0	9 4 2
1923 ..	8 17 6	9 2 0	10 5 0	10 10 0	10 10 0	10 10 0	9 15 0	9 0 0	8 15 0	8 15 0	8 19 0	9 5 0	9 9 10
1924 ..	9 5 0	9 5 0	9 5 0	9 5 0	9 5 0	9 2 6	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 0 0	9 2 3½
1925 ..	9 0 0	9 0 0	9 0 0	9 0 0	8 15 0	8 10 7½	8 10 0	8 10 0	8 10 0	8 4 0	8 0 0	8 0 0	8 11 7½
1926 ..	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 0 0	8 7 6	8 10 0	8 10 0	8 10 0	8 10 0	8 3 11½
1927 ..	8 10 0	8 10 0	8 10 0	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 2 6	8 3 0	8 5 0	8 5 0	8 4 10
1928 ..	8 5 0	8 5 0	8 5 0	8 5 9	8 6 3	8 6 3	8 10 0	8 10 0	8 10 0	8 10 0	—	—	—

AEVRAGE MONTHLY PRICES OF EAST COAST HEMATITE AT MIDDLESBROUGH.

Year.	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1915 ..	83 11	88 6	94 8	107 0	102 6	101 3	98 9	98 7½	96 6	104 0	124 1	130 0	106 11½
1916 ..	133 9	140 0	136 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	128 1½
1917 ..	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6
1918 ..	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6	122 6
1919 ..	122 6	122 6	122 6	122 6	179 2	190 0	197 6	200 0	200 0	200 0	200 0	200 0	171 4
1920 ..	220 0	220 0	240 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	260 0	251 8
1921 ..	240 0	220 0	180 0	180 0	180 0	160 0	160 0	160 0	137 0	127 6	117 6	104 6	162 2
1922 ..	97 6	91 7½	100 0	98 6	97 1½	94 7	93 6	90 9	89 7	91 10½	93 0	93 2	94 5½
1923 ..	94 6	104 9	122 0	126 10½	122 0	115 3	107 0	98 8½	98 10½	99 1½	100 6½	102 3	107 10½
1924 ..	102 4½	101 3	99 7½	99 0	98 9½	97 4½	95 3½	93 1½	90 7½	88 0	88 4½	88 6	96 2½
1925 ..	87 5	85 9	84 7½	82 6	80 10½	79 3	77 1½	75 7½	75 0	74 3½	74 9	76 0	79 5½
1926 ..	77 3	77 9	77 3½	76 3	77 4½	78 0	79 8½	81 9	83 4½	87 7½	92 6	90 5½	81 7½
1927 ..	90 0	90 0	86 3½	83 1½	80 6	78 0	76 6	75 4½	75 0	72 9	71 9	71 1½	79 2½
1928 ..	69 7½	69 7½	69 9	70 0	70 0	69 3	68 7½	69 2	70 0	70 0	—	—	—

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

PIG IRON

REGISTERED TRADE MARK

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE.

WILLIAM JACKS & COMPANY,

19, ST. VINCENT PLACE, GLASGOW.

ZETLAND ROAD, MIDDLESBROUGH.

SMALL ADVERTISEMENTS.

SITUATIONS VACANT AND WANTED.

WANTED, an experienced Foundryman; able to take Foreman's position in foundry of progressive Engineering Works in Yorkshire; must be accustomed to dry and green sand moulding and have cupola experience.—Apply, giving age and full particulars, to Box 860, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

PATENTS AND TRADE MARKS.

INFORMATION HANDBOOKS, Advice, and Cons. free; King's Patent Agency, Ltd.—B T. KING, C.I.M.E. (Regd. Pat. Agent, G.B., U.S.A., and Can.), 146A, Queen Victoria Street, E.C.4. 40 years' refs. 'Phone: 0682 Central.

THE owner of British Patent No. 247,683 relating to "A Machine or Apparatus for Treating or Preparing Moulding-sand and for Analogous uses," is desirous of entering into negotiations for the grant of licences or otherwise, under reasonable terms, for the purpose of exploiting the invention and ensuring its full development and practicable working in this country. — For particulars, address, ARTHUR SADLER, 44, Waterloo Street, Birmingham.

THE proprietor of British Patents Nos. 227,963 and 228,070 (Divisional), both dated November 27, 1923, relating to "Improvements in machines and methods for making foundry moulds and cores" and "Vents for moulders' flasks and core boxes," respectively, is desirous of entering into arrangements by way of a licence or otherwise on reasonable terms for the purpose of exploiting the above patents and ensuring their practical working in Great Britain.—All inquiries to be addressed to B. SINGER, Steger Building. Chicago, Illinois.

PROPERTY.

11 ACRES WORKS SITE, SHEFFIELD.

145,000 Sq. Ft. of SHOPPING,
Compact and Convenient.
SIDING CONNECTIONS
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